MEDICAL DISORDERS OF THE LOCOMOTOR SYSTEM



Erythema annulare rheumaticum

This is regarded by some authorities as the true rheumatic eruption (see Chapter XI)



Erythema nodosum

The ætiology of this condition is discussed in Chapter XIX

Frontispiece]

MEDICAL DISORDERS

OF THE

LOCOMOTOR SYSTEM

INCLUDING THE

RHEUMATIC DISEASES

BY

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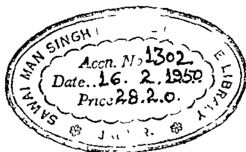
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EDINBURGH

E. & S. LIVINGSTONE LTD.

16 AND 17 TEVIOT PLACE

1947



Made and Printed in Great Britain by Neill & Co, Ltd, Edinburgh.

TO

MARY

AND

ANTHONY

PREFACE

MY object in writing this book is to bring under one cover the available information on the subject of the medical locomotor disorders, a branch of medicine which has occupied my attention for many years. So far as I know, this has not been attempted before, and if this attempt of mine will in any way promote more intensive study, I feel my efforts will not have been in vain.

Pioneer efforts are, I well know, attended with difficulties and many errors of judgment which experience and time alone can correct, but I have found the study of these disorders very much an uncharted sea, and for this reason I must crave the indulgence of the reader.

Nevertheless, I believe that the foundation on which the book rests is sound, for the locomotor system, both anatomically and physiologically, makes a satisfactory basis for practice, research, and teaching, and gives fairly neat, rounded boundaries. One exception should perhaps be mentioned. Logically, the system should also embrace the cerebrospinal system, but I deemed it wise to exclude it, as it already represents a well-defined department of medicine. Apart from this, the disorders of one system are often reflected in another, and no attempt is intended here to isolate the study of these disorders but rather to regard them as within the province and interest of the general physician.

I have deliberately given much prominence to the rheumatic diseases, not only because they form an important part of the subject, but also because they are well recognised here and the world over as a social scourge and a national problem. The classification of the rheumatic diseases without final knowledge of their ætiology is open to criticism, and in the present state of our knowledge no useful purpose is served by making rigid classifications. The first chapter is therefore devoted to a consideration of this question, in order that the rheumatic diseases may fall more easily into their place in the field of locomotor disorders.

As with other systems, chapters in this book have been devoted to anatomy and physiology, but it has to be recorded that there is a painful lack of reliable information on the physiological side. When more is known, for instance of normal synovial fluid, it is only then we can hope to study and treat effusions with more precision.

I realise only too well the lack of proportion that appears in some parts of the book, in that I have given too much space to some disorders and too little to others. This is a fault which has grown with me as a student of the subject, and which I had not fully realised until the book came to page proof.

Some recent research work carried out by Dr Shackle suggests, in his opinion, that some of the conclusions he has reached on the

subject of the estimation of uric acid in the blood and plasma may have to be revised

I have been singularly fortunate in obtaining great help from contributors, especially with regard to the diseases of bone, and I wish here to record my profound indebtedness to them.

I should also like to thank Lord Horder for his constant encouragement, his vigorous interest in "rheumatism," and his readiness always to consider new concepts Professor Bruce Perry has also been kind in criticising the chapters on Rheumatic Fever.

I am grateful to Drs C. F Hawkins, M. Sadique, and M. McKenzie for re [illegible]

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journ [illegible]

British Medical Journal, *Lancet*, *Medical Press and Circular*, *Post-Graduate Medical Journal*, *Annals of Rheumatism* and the *Journal of Physical Medicine and Hygiene.* Acknowledgement in certain cases has been made in the text or in connection with illustrations.

Lastly, I should like to express my appreciation of Messrs. Livingstone's untiring courtesy and patient good will, and especially my debt to Mr Charles MacMillan.

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CONTENTS

CHAPTER I

THE DEFINITION AND CLASSIFICATION OF THE RHEUMATIC DISEASES

IT seems clear that the chronic rheumatic diseases form a large part of a greater family, the medical disorders of the locomotor system The term rheumatism is however useful and convenient, and it has age and tradition on its side. The suggestion that the rheumatic disorders can be defined as "painful locomotor disorders of unknown ætiology" is a good one and tends to give definition to a subject which badly needs it Nevertheless the time must come, and may even come soon, when the ætiology becomes clearer Such a definition could only therefore have a temporary status, but it seems a good one at the present time

The Nomenclature Committee of the International League against Rheumatism is said to have gone through sixty different methods of nomenclature from different countries (Fox and van Breemen, 1934) Every possible basis was used clinical, anatomical, pathological, radiological and so on Little would be gained by enumerating or quoting these classifications of rheumatism, but three will be analysed so that current thought on the subject may be understood

The Ministry of Health classification (Glover, 1924) obviously needs study, for it represented the most careful work extant at that time

Dr Glover s Classification

A THE ACUTE RHEUMATIC GROUP	(1) Acute rheumatism
	(2) Sub acute rheumatism
B THE FIBROSITIC GROUP	(1) Muscular rheumatism
	(2) Lumbago
	(3) Sciatica and brachial neuritis
C THE ARTHRITIC GROUP	(1) Rheumatoid arthritis
	(2) Osteoarthritis
	(3) Gout
	(4) Unclassified arthritis

At this stage, it becomes necessary to decide what qualities a classification should possess to be of the greatest use Firstly, it must be complete and embrace everything which could be met with in the course of the work, and nothing which was outside the field. Secondly it must be helpful that is to say, some definite advantage must accrue from its use. Lastly it must not group together things which do not possess similar qualities

From the point of view of completeness, Glover's classification seems to fall short The skin lesions and nerve lesions which could

So that, on analysing, say, sciatic neuralgia, we find one case due to Paget's Disease, and the next may be due to a prolapsed nucleus pulposus, or on analysing osteoarthritis one case may be due to Paget's Disease and the next to trauma If the first attitude is taken and the disease index simply records the presumably primary complaint (such as Paget's Disease), the amount of information is minimised, and the study of locomotor disorders is not furthered

As there are only two great groups of non-specific chronic arthritis it really matters little what they are called, but in this book Group I has been called rheumatoid (or infective) arthritis, in order to comply with the College of Physicians classification, and Group II osteoarthritis The term rheumatoid (or infective) arthritis includes the "rheumatoid type" of the College of Physicians classification

The disease index for the main syndromes has already been set out, but the complete index is naturally large and the specific arthritides are, of course, set out under their own names One section deals with arthritis associated with general medical syndromes and in this case the type, either I or II, is set out, but it may vary in different cases. For instance, Schönlein's purpura may produce a rheumatoid type of arthritis which clears up but leaves an osteoarthritis as a permanent legacy

It seems quite clear that at the present time the recording and indexing of the locomotor disorders has been somewhat neglected and that a great deal of clinical work of the highest standard is not being fully utilised In any case Poynton and Schlesinger seem to have reason on their side when they say the primary cause of these conditions must be the basis of any satisfactory *classification,* and we are not in a position at the present time to make such an attempt.

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CHAPTER II

CLINICAL EXAMINATION OF THE PATIENT SUSPECTED OF SOME LOCOMOTOR DISORDER

IT is an axiom taught to every medical student that complete physical examination coupled with a careful history taking is the *sine qua non* of clinical practice As time goes on, however, and the student becomes an experienced practitioner he may find that he is able to dispense with this complete and formal examination, because his experience allows him to make short-cut deductions which he has found to be reliable in the past Such a practitioner turning his attention to medical locomotor disorders will find himself disappointed, for there are no short cut deductions in this branch of medicine Symptoms which appear to be useful in locating the source of the trouble are a snare and a delusion, for as often as not they are eventually found to be attributable to causes far removed No amount of experience will obviate the necessity for a complete formal examination, and the following plan is based on that conclusion

In order to make the examination as short as possible without missing anything of the slightest importance it is essential to have a routine sequence An unvarying order has two great advantages, nothing is overlooked, and the maximum convenience of the patient is secured

History Taking

It is a good plan to start by asking the patient his *present* complaint If a satisfactory answer can be given, a good deal of time will have been saved, but in practice the past is so bound up with the present, in these matters, that it is seldom an adequate answer is received In this case, the best plan is to ask the patient to commence his history from the beginning, and to combine the past and present history in one

Past history should include everything the patient says, noting particularly the *duration of symptoms* and the *part first* affected In addition, certain direct questions should be asked if the answers have not been volunteered It is a mistake to be too detailed, in the end the wood cannot be seen for the trees, but certain information is essential, and the following points must be raised

Occupation	Cold fingers
Diet	Serum sickness
Living conditions	Venereal disease.
Residence in the tropics.	Skin disease.
History of sore throats and dental history	Constipation and indigestion
Injury.	Courses of drugs (sulphonamides, arsenic, etc.)

Past infectious diseases and exanthemata
Rheumatic fever.
Nodules
Foot trouble.

For *women patients*, menstrual and menopausal history.

This is simply a list of those things which have a tendency to be overlooked Naturally it is incomplete, but most of the other important points arise automatically.

Family History.—Ask direct questions on·
Hæmophilia
Metabolic disorders (gout, alkaptonuria)
Tuberculosis (pulmonary or bone and joint).

Physical Examination

The following sequence is adopted and it is most convenient and least tiring for the patient

On arrival at the hospital or consulting room the patient's *height* and weight are taken, the temperature, pulse and respiration are recorded and a routine examination of the urine is made

After the history has been taken, the patient undresses and *lies* supine on the couch, and the examination is conducted as follows

(*a*) *General Condition* —It is wise to try not only to assess the patient's general physical condition, but also to obtain some insight into his general mental make-up In certain conditions, notably infective arthritis, there is a considerable psychological element, and it is as well to be aware of this

(*b*) *Examination of the eye grounds, the reaction of the pupils, with a rough test of the cranial nerves* —Many cases, particularly of osteo-arthritis, are associated with arteriosclerosis and with hypertension An examination of the eye grounds, particularly after experience has been gained, will often give forewarning that such a complication may be present

As pain is a prominent part of many medical disorders of the locomotor system, the aim must always be to exclude all possible causes The reaction of the pupils to light and accommodation, especially if taken in conjunction with the state of the knee jerks, is an observation which should always be recorded A rough test of the cranial nerves is necessary because cases of muscular dystrophy, especially of the facio-scapulo humeral type may start with pain in the limbs This is not, of course, by any means the only reason, but is given as an example of why this examination must be included.

(*c*) *Examination of the tongue, teeth and fauces and temporo-mandibular joint Transillumination of the antra.*—It is not proposed at this point to discuss the very vexed question of focal sepsis It is, however, necessary to say that it is a very poor service to a patient to miss a focus of sepsis if it is present In these circumstances removal leads, as a rule, to permanent and complete cure It is the greatest mistake and obviously very bad practice to remove teeth, tonsils and other organs on the chance that they may be an important

factor. It is, however, a greater mistake not to remove them when they are the *fons et origo* of the disorder.

(*d*) *Examination of the neck, cervical spine and the front of the chest Estimation of the blood pressure Range of movement in the shoulders*.—At this stage the neck is examined for glands in the triangles, as these may often be found in cases of infective arthritis, and the localisation and character of the glands must be determined in all cases It is sometimes easier to palpate the paraspinal muscles in the cervical region while the patient is supine Rotation of the head, which is seldom seriously interfered with, should be tested, and forward bending of the head and neck will often give a clue to disorder of the spine and its ligaments lower down, as the ligaments form a continuous band down to the sacrum. The position and size of the thyroid may be determined now, and it is a good plan to search, especially in elderly people, for an enlarged left supraclavicular gland

Fully circumabduct the shoulders, the arms and hands lying in a semicircle round the head Palpate the brachial plexus for tenderness on both sides

The front of the chest is examined by palpation, percussion and auscultation in the usual way, and the blood pressure is taken

In addition to this always palpate the intercostal muscles and the costosternal joints, as these are the site of the unexplained pain in the chest in some cases

(*e*) *Examination of the abdomen with the superficial reflexes*.—Especially palpate the gall-bladder and appendix regions, examining also for the size of the liver and spleen

(*f*) *Examination of the joints of the hands, elbows and radio-ulnar joints and their movement. Tenderness of nerves, reflexes and muscle strength*.—It is as well to adopt a method of notation for the small joints of the hands. Calling the thumb 1, the fingers are numbered on both sides, the little finger, of course, being 5 In addition, note the change present and which joint is affected For example

R2 m c p Sw R3 m p D L1 c.m.c P & T.

would mean the metacarpo-phalangeal joint of the right index finger is swollen, the mid-phalangeal joint of the right middle finger is deformed, and the carpo-metacarpal joint of the left thumb is painful and tender. To the uninitiated this may seem slightly pedantic and unnecessary This is not really so, for on seeing a patient at a later date it enables a complete check-up to be made quickly Patrick's Goniometer (*B M J*, August 19, 1944, p 246) is invaluable for the measurement of movement at the radio-ulnar joints, and a small protractor can be used for the elbows and wrists.

With regard to reflexes it is usual to test the supinator, biceps and triceps jerks Strength is usually tested by the grip, a dynamometer being used if desired then flexion and extension of the wrists, elbows and shoulders

Two nerves can be palpated easily, the musculo-spiral in its groove as it passes round the humerus and the ulnar nerve at the elbow.

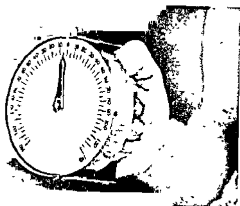


FIG 1
Patrick Goniometer held half-way between pronation and supination (Figure 0 on the scale)

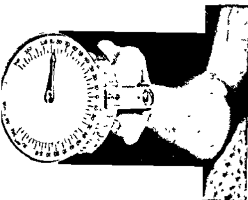


FIG 2
The Goniometer in full pronation

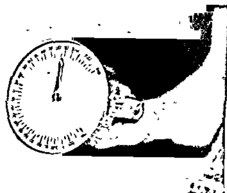


FIG 3
The Goniometer in full supination

(*g*) The so-called *Lasègue* or *straight-leg raising test* is performed, and the *movements of* the hip and knee joints are observed The feet are examined and the state of their ligaments and the mobility of the joints tested Reflexes are tried Tenderness of nerve and muscle is looked for.

The straight-leg *raising test is a useful one* for testing the structures at the back of the leg, thigh and low back Care must be taken that the back lies quite flat on the couch, and that no tilting occurs. If a positive test is shown, its significance must not be over emphasised It does mean *that one or more of the* structures mentioned above are at fault, but it *is not true that it is a test* for sciatica. If, however, it is positive, it is wise to measure both thighs six inches above the upper border of the patella, and the legs five inches below the lower border, as wasting of muscles is a common finding in some nerve lesions

Any swelling of a joint must be measured and compared *with the other side if it is sound.*

Examination of the feet will, of course, note the presence of pes cavus or flat foot Tenderness of the metatarso-phalangeal and mid-phalangeal joints should be recorded.

Tenderness of nerves, especially the posterior tibial, should be looked for, and the reflexes, including the plantar reflex, tested

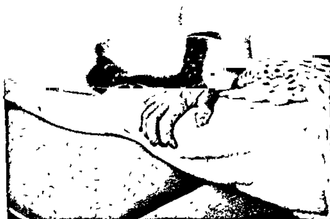


Fig 4

External rotation of the thigh This is usually the first movement lost in hip lesions



Fig 5

Forward bending —Fully explained in the text The knees are usually held down by the examiner

The usual way to test strength of muscles is to try flexion and extension at each joint, but the important movement in early lesions of the hip joint is external rotation and abduction

(h) With the thighs held down the patient is asked to *lean forward and touch his toes* This is rather a complicated test to evaluate accurately In its simplest form it is an indication of the mobility of the lumbar spine, but before this can be accepted several other conditions must be fulfilled. In the first place, it must be ascertained by palpation that the hamstring muscles are not unduly short, and



FIG 6

Upward stretching —Note the movement is not quite full, as the dorsal spine is slightly stiff



FIG 7

Testing shoulder movement in a downward and backward direction This movement is not full, the upward-turned thumb should reach within 4½ inches of the seventh cervical vertebra in a man of 25 years The movement of the dorsal spine is tested in Figs 6 and 10

it must also be clear (see under g) that the hip joints have a full range of movement A tender and inflamed sciatic nerve will interfere with the test, and so will myalgic conditions situated either in the back of the thigh or in the low back In making the examination, therefore, it is as well simply to note that in trying to touch his toes lying the patient fell short by so many inches At other stages any extraneous cause will be found

(j) Whilst leaning forward the back of the chest is percussed and auscultated. A number of cases will be found complaining of pain in the arms or back who are suffering from pulmonary or pleural lesions Bronchiectasis, for instance, may give rise to pains anywhere in the body, and it is, therefore, important to exclude such a complication On more than one occasion a patient referred for osteoarthritis has been found to be suffering from carcinoma of the lung

Fail
and
of the shoulders (Dupley's Syndrome) and a fixed dorsal kyphosis. These two can be separated by putting the shoulders through a full range of movement and asking the patient to put his hands behind his back If the range of movement in the shoulders is full, then the dorsal spine should be carefully examined If neither of these tests reveals any abnormality, a variety of lesions must be looked



Fig 8



Fig 9

Cervical spine No rotation of the head must be allowed in this manœuvre or in Fig 9

for and it should be remembered that weakness may (occasionally) be the cause, and that a really stiff neck may be a factor

(*k*) With the hands down again the cervical and dorsal spines are tested for movement by lateral bending and torsion of the trunk The back of the neck and its muscles are examined The chest expansion is measured Testing the cervical spine for movement is a special manœuvre Standing on the right of the patient the left hand is placed round the neck at the back so that the cervical spine (so to speak) lies between the palm and the fingers Holding the top of the head with the right hand, it is gently moved sideways in both directions As the head moves the flexibility of the spine can be noted with the left hand The important point is not to let the head rotate lateral bending is the essential movement Rotation of the head is seldom interfered with but should be tested next

Chest expansion is naturally conditioned by many considerations and it may be difficult to evaluate them all but the point at issue here is interference with the range of movement in the costovertebral

joints. In certain conditions, such as ankylosing spondylitis, this is seriously interfered with

(l) The patient is then asked to *turn on his face*: the way he does so is noted, hyperextension of the hips is tried, and tender spots in any of the spinal and paraspinal muscles are looked for. The posterior sacral ligaments are palpated, as are also the posterior muscles of the buttock, thigh and calf. Tenderness is sought for in the more superficial nerves. This is the stage at which extraneous

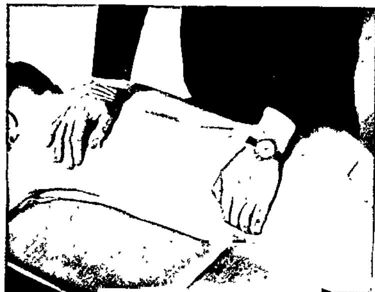


FIG 10

Dorsal spine —The right hand fixes the spine and the left works against it

causes for a positive straight-leg raising test are usually found. Myalgic spots in the hamstrings and gastrocnemii are easily missed.

Mobility in the dorsal spine is estimated The patient is asked to relax with the arms over the edge of the couch Standing on the right side of the couch, the right hand fixes the spine at various levels by pressure on the ribs as near the mid-line as possible The left hand raises the anterior superior spine on the left side, giving a twisting movement to the whole spine. The two hands work against one another and the degree of mobility at the section of spine steadied by the right hand can be fairly well estimated The process is reversed for the opposite side

The pelvic twist —Standing on the left of the couch the patient is asked to lie on his right side, the upper leg being allowed to hang over the edge of the couch. The under arm is pulled so as to give some torsion to the spine, the upper shoulder is held back with the left hand and a downward-twisting movement is given to the left anterior superior spine by the right arm This is valuable but it

must not be undertaken lightly Gentleness is the keynote The test gives information as to the mobility of the spine as a whole By flexing the upper leg a varying degree at the hip joint the maximum stress is felt at different points in the spine The further the hip is flexed the higher the stress is felt. *Do not use the test unless you must have some of the information it gives and never use it in old people.*



FIG 11

The pelvic twist—A caution is given against the indiscriminate use of the test The left hip may be flexed at varying angles

(*m*) In certain cases of unexplained pain in the arms and legs additional blood-pressure readings are taken in the arms and legs and oscillometric readings taken

(*n*) *The patient is asked to stand up and touch his toes*—The general posture is noted, deviations of the spine in any direction are observed, and the degree of lumbar lordosis,

CLINICAL POINTS IN JOINT EXAMINATION

1 Pain
2 Swelling
3 Tenderness.
4. Stiffness
5. Limitation of movement.
6 Crepitus
7 Muscle-wasting
8 Deformity.
9 Œdema
10 Involvement of surrounding structures.

1. Pain

Pain is such a constant and outstanding symptom in the rheumatic diseases that it is felt that as much knowledge as possible should be acquired as to its characteristics

Sir Thomas Lewis and his associates have persistently attacked this problem, and their work has recently been gathered together into book form (Lewis, 1942) Full references will be found in Lewis's book The following important points helped in the study of rheumatism. Lewis tried stimulating the skin in various ways—with a heated wire, a needle-prick, pulling a hair, and pinching it with forceps—and he found that if the patient could not see what was being done he was not able to say what method of stimulation had been employed, because the type of pain produced was unvarying. In addition, stimulation of a small cutaneous nerve produced the same type of pain The description of the pain depended on its duration—if short, it was called "pricking," if prolonged, "burning." This single pattern of skin pain is interesting and important, for it enables one to distinguish pain due to involvement of the skin from that found in other structures It has been tested with bee stings (used in the course of treatment) and nettle stings. The latter seemed to vary to some degree, but mostly because they had a character superadded to their basic quality

Lewis next investigated muscle by injecting it with hypertonic saline or buffered acid solutions He injected the solution into a muscle on one side, and on the other worked the symmetrical muscle under ischæmic conditions He found the two pains to be indistinguishable He was unable to describe the pain, but was able to say that it was different from skin pain It partakes more of an aching character, and is familiar to anyone who has used unaccustomed muscles the previous day Perhaps it is felt best in the thigh adductors after a long day's hunting The character of the pain is unvarying Similar conclusions were reached with regard to the pain produced by injury to web, tendon, periosteum, joints and deep fascia In applying this research to the problem in hand, skin pain was easily separable from muscle pain Unfortunately, the pains from tendon and muscle, though different from each other, have qualities which elude description It is true that muscle "aches" and tendon "hurts," but every patient has a different way o describing his pain, and only those with a fair vocabulary can g about the description with a chance of being understood

With regard to the pain in joints, it seems likely again that thi is characteristic Presumably all joint pain arises in synovia membrane, as articular cartilage is relatively insensitive Patient are liable to localise their pain fairly accurately With the eye shut, they can tell which side of a joint is being hurt, but the pai is described as a rule as "sharp" The pain of arthritis is "deep an boring," and does not closely resemble the pain produced in a join by a hypodermic needle. In the course of treatment a good man joints have been injected with lipiodol, which causes some pain fo

about forty-eight hours This is the "same" pain as the arthritic condition itself caused, and it is "different" from skin and muscle pain From personal experience, skin and muscle pain, and generally tendon pain, is easily recognisable Joint pain may present more difficulties

In studying this question of pain the degree of joint change which is necessary to produce pain is found to be very variable For instance, two patients may have a degree of joint change which by clinical and ancillary examination appears to be comparable One suffers the most intense pain, and the other has none More remarkably the same patient may have a degree of arthritis in both knees; one knee appears by X-ray to be in a more advanced condition than the other, yet pain is felt in the better knee and none in the other

Referred somatic pain—Kellgren (1937–39) in an extensive research has been able to formulate certain important generalisations The injection of small quantities of hypertonic saline produced artificial lesions in various structures of the body He concluded that

1 Pain is well localised in superficial structures but poorly localised in deep structures Localisation in deep structures may be so inefficient that the pain not only possesses two components, the primary pain and the secondary pain, but may be referred to another part of the body altogether

2 Pain in muscle may be referred to any part of the segmental root supply of that muscle The distribution of the pain for a given muscle is roughly the same in different individuals The trunk as would be expected gives the clearest indication of segmental distribution and in this case the pain is particularly interesting as clear dorsal and ventral components can be recognised, the chief localisation depending upon the site of the lesion If the pain is very severe adjoining segments may share in the reference Injection of the interspinous ligaments was found to give a very clear indication of this segmental distribution and by this means Kellgren constructed a map of the deep segmental distribution In the trunk this map corresponded well with that of the known superficial sensory supply but in the limbs these two types of supply did not correspond

Lewis and Kellgren (1939) noted that injection of the interspinous ligaments besides producing referred pain and areas of hyperæsthesia also produced areas of muscle spasm which showed deep tenderness these phenomena were all confined to a segmental distribution

These observations are of importance, as they draw attention to diagnostic pitfalls due to the secondary effects of a primary lesion overshadowing the effects of the primary lesion itself, and thus causing error

3 The deeper the source of pain the worse the localisation The well known reference of pain from the hip to the knee can be shown by experimental means, but pain in the knee being relatively well localised does not cause the reverse effect In general, the deeper a

structure lies the more likely is it to give rise to diffuse segmental pain

Kelly (1945) has reviewed the application of these findings to the referred pain of fibrositis, and has shown by experimental means that the reference appears to be through the sensitive fascial planes and the perimysium.

Cutaneous hyperæsthesia may prove misleading as the tenderness produced by the palpation of such areas may be confused with the tenderness arising from deeper structures Two means are available for circumventing this difficulty Firstly, pinching or pricking of the skin will detect the condition, and secondly, it may be eliminated by surrounding the area by an intradermal ring of procaine, thus allowing adequate deep palpation to be carried out without interference. It is possible that the therapeutic effects of the ethyl-chloride spray may be partly due to the elimination of skin hyperæsthesia.

More of a research than a clinical procedure, paravertebral block may in obscure cases indicate the segmental nature of different types of pain

Subjective pain —The role of mental make-up and other subjective factors upon real pain is well known and does not require detailed consideration It must be admitted that though clinical assessment of the patient gives a rough idea of the importance of this factor in the individual case, many errors have their root in this difficulty.

At the moment Lewis's (1942) work on the "nocifensor" system appears to have no practical bearing on the clinical elucidation of pain There are unfortunately no satisfactory universal tests of the pain threshold in man, in fact little serious work on this subject has yet been performed Libman (1934) has pointed the path to be followed by his development of the pressure test over the styloid process of the mastoid, to determine the individual patient's response to a standard pain Much further work remains to be done before the subject can be regarded as being satisfactorily treated

It seems possible that many of the X-ray changes produced by non-specific arthritis could be due to changes in the vascular supply to joints. Lewis and Pochin (1937) showed that when asphyxia of the upper arm was produced by compression with a cuff, and the fingers became anæsthetised, the intensity of pain response increased and became diffuse In addition, however, there was an increase in the pain responses from deeper-lying tissues They think this was due to temporary local damage to the nerves at the point of compression

It is possible to conceive long-continued poor vascular supply to a joint producing damage of such a character as either to bring pain into consciousness at an early date or to make pain, which would be felt in any case, more severe. Oscillometric readings give results which are anomalous and dubious

The recent work of Erlanger and Gasser (1927) shows that there are three sets of fibres, termed a, b and c, in sensory nerves. These fibres have different electrical responses Fibres a and b have *a rapid* and fibres c *a slow* transmission time Sensations of pain are carried

by both types of fibre, giving rise to Lewis's primary and delayed response

Fibres a and b are first affected by ischæmic conditions, whilst fibres c succumb first to the effect of cocaine

The transmission time in fibres a and b is twenty times more rapid than in fibres c At the present time it is uncertain whether these fibres, apart from their differences in transmission time, also carry different types of pain

Specialist physicians should make a close study of pain, as it is such a constant symptom in the rheumatic diseases

2. Swelling

Although swelling is such a constant physical sign in chronic arthritis, it appears likely that there are only a few common types. All swellings can be grouped into fluid, synovial and bony swellings. One of the commonest traps is to regard a joint as swollen because the periarticular structures are wasted

(a) *Fluid swelling* —This may occur as a synovial effusion, or as an effusion into a bursa The examination of these swellings will follow the usual lines

Fluid swellings, either bursal or articular are very commonly met with in infective arthritis, and it is helpful to take samples of this fluid The cell count and differential count is of some help—not only in establishing the diagnosis, but it is also a help to prognosis. So far, very few examinations of this kind have been recorded, but an indication of what may be expected is to be found in the chapter on synovial fluid A synovial effusion in infective arthritis indicates an active process within the joint, and generally suggests rest for a limited period In osteoarthritis effusions occur but are rare, and it is still uncertain what their significance may be On analogous lines, they probably indicate a worsening of the joint condition, but it is by no means certain

It will be wise to mention here that a joint with synovial effusion needs careful diagnosis for the effusion of say, intermittent hydrarthrosis needs quite different treatment The bilateral effusion into the knees in syphilis is painless and should not lead to difficulty.

(b) *Synovial swelling* —This is a very common finding It occurs principally as the result of an incompletely resolved synovial effusion in infective arthritis or, more rarely, in the rather later stages of osteoarthritis As an index to activity it has value, but in infective arthritis it may become a permanent feature even after the disease has ceased to be active although the swelling often gradually disappears as time goes on and the membrane shrinks down In osteoarthritis it is most commonly seen in cases during the temporary stage of inflammation, when the joints become hot and the skin over them becomes red, and a general "flare-up" occurs It takes a considerable time before the joints recede to their former condition, and this stage of classical inflammation nearly always leads to advance in the condition, and is one of the strongest arguments in favour of an inflammatory or bacterial ætiology

(c) *Bony swelling*—This is especially noticeable at the end of the long bones in osteoarthritis It may be quite an early feature, and it seems as if there is hypertrophy of the bone, for the ends of the bones, especially at the knee and ankle, are increased in girth. A local periosteal reaction with the laying-down of fresh bone may occur Diagnostic difficulties must be remembered, for in one case the swelling was due to a syphilitic periostitis, and in another to a sarcoma of a femoral condyle, but in most cases it appears concurrently with the osteoarthritis, and no reference to it has been found in the literature These swellings have never been found in infective arthritis

3. Tenderness

Areas of tenderness must be accurately located or they lose their diagnostic value. Any one of the following structures may give rise to tenderness skin, fat, fascia, *muscle, nerve, or synovial membrane.* In addition to its own inherent difficulties, the problem is also one of location in depth. Lewis's work on pain is of assistance in separating tenderness in skin and muscle, as the pain arising from these is usually characteristic Skin tenderness is, of course, noticed with very superficial stimuli. The question of tender fat is important The fat may appear in the form of panniculitis, where the fat is laid down in the lobules in *the superficial fascia, and strands of* fibrous tissue may be attached round it to the epidermis. This may occur in any patient who is putting on weight fast, but it is dignified with the title "panniculitis" only when [illegible] that it gives rise to tenderness is [illegible] symptoms [illegible] round the joi[illegible] (Fig 12) and gives rise to the condition known as *"adiposis dolorosa juxta-articularis"* This can be, and very often is, confused with a true arthritis, and may account for some of the diagnoses of menopausal arthritis It may be an atypical form of Dercum's Disease, but it is unlikely to be *due to lymphatic disturbance, and the swellings* seldom become inflamed The condition may be endocrine in origin.



FIG 12

Adiposis dolorosa juxta-articularis, sometimes confused with a true arthritis The two conditions may appear together

Round most joints it is almost impossible to separate muscle pain from fascia pain Tender nerves are fairly easy to diagnose as the nerves tend to become slightly thickened and "roll" under the finger. When pressed they give rise to "pins and needles" in the area of their distribution

It is difficult to test the synovial membrane itself except in the

case of the knee joint, but in cases where it is hypertrophied (as round the ankle joint and the wrist) it is sometimes possible to be sure that it is tender Even then the pain produced is not the same as the patient complains of in cases of true arthritis

Most physicians attach importance to the question of tenderness, and this has reason on its side On the whole, however, it is a deceptive sign and of little value in separating infective arthritis from osteoarthritis

4. Stiffness

This is one of the interesting symptoms of chronic arthritis In many cases muscle pain is associated with stiffness In healthy subjects stiffness follows over-exercise and Lewis (1936) thinks that the pain and stiffness follow the accumulation of metabolites in the muscles Pain of this sort and stiffness follow muscle work under ischæmic conditions, but disappear very quickly when the blood supply is restored Unfortunately, this is not at all the story in arthritis The stiffness is greatest after rest, and is most noticeable in the morning As the muscles are exercised, the stiffness wears off. The same remark applies to the stiffness which follows the use of unaccustomed muscles

The degree of stiffness is a fair indicator of the activity of the process

5. Limitation of Movement

This may be due to either pain stiffness, or mechanical causes Apart from mechanical causes, it is a good indicator of past and present activity, but it must be considered in relation to its cause Mechanical causes are, of course fibrous and bony ankylosis in infective arthritis and capsular contraction and osteophytes in osteoarthritis Other rare causes exist

6. Crepitus

There are three types of crepitus A rather leathery crackling type, which seems to originate in the synovial membrane and is produced in moving the joint Periarticular crepitus is easy to recognise if properly located Bony crepitus may be heard in any joint but is generally best appreciated in the spine or pelvis. It is generally evidence of old activity—although this is not proven - and is noticed most frequently in the pelvis or lumbar spine in burnt out ankylosing spondylitis, or osteoarthritis of the hips

7. Deformity

Deformity is an aftermath of chronic arthritis

8. Œdema

Œdema is a good negative point, for it rarely occurs in chronic arthritis and, if present may be an indication to look for a possible

alternative diagnosis It occurs with greater frequency in cases of *specific arthritis*

9. Involvement of Surrounding Structures

The diagnosis of arthralgia depends partly on exclusion. Tenosynovitis and painful and tender nerves and the question of painful fat has already been mentioned under the heading of "Tenderness"

10. Muscle-wasting

Muscle-wasting appears in a very marked degree in rheumatoid arthritis Generally it is explained as being due to interference with trophic fibres which pass in, or near, joints The modern view is apparently against this Disuse, again, is not in favour as an explanation, but it seems likely that it takes some part

Sweating test—Guttman (1940) devised a thermo-regulatory sweating test By placing the patient in a radiant-heat bath and covering the skin with a dye he has been able to compare the sweating *in different parts of the body The dye used is sodium chinizarin* 2–6 disulphonate (B W & Co) in starch The dye changes from light grey to purple in contact with sweat It is a useful test, as it is entirely objective, but its only use is to show the integrity of the sympathetic fibres running along the peripheral nerves.

The electromyograph is capable of measuring action potentials in muscles. It has recently been revived in an improved form and it will be of great service in the study of locomotor disorders. The following is an authoritative account of the present state of its development

ELECTROMYOGRAPHY

It was Adrian (1925) who first suggested that electromyography might be of value in clinical medicine Since the publication of his paper, electromyography has been used spasmodically, the electrical activity from the muscles of patients suffering from spasticity, tremors and other pathological conditions has been recorded, and the method has proved of value as a diagnostic agent

Recently, however, the recording of action potentials from muscles in man has assumed more clinical importance, for with modern apparatus it is possible to detect not only motor unit action potentials, but also fibrillation action potentials

Schiff (1851) discovered that, when viewed directly, denervated voluntary muscle was in a state of continuous surface agitation, which he found to be due to minute contractions of isolated areas of muscle. In the rabbit, this condition, known as fibrillation, commences about four days after a peripheral nerve has been cut.

Since Schiff's time, fibrillation has been studied by a number of observers. Denny-Brown and Pennybacker (1938) showed that, in the human subject, specific action potentials can be recorded from denervated muscles, and Eccles (1941) showed that the unit concerned in the activity is a single muscle fibre

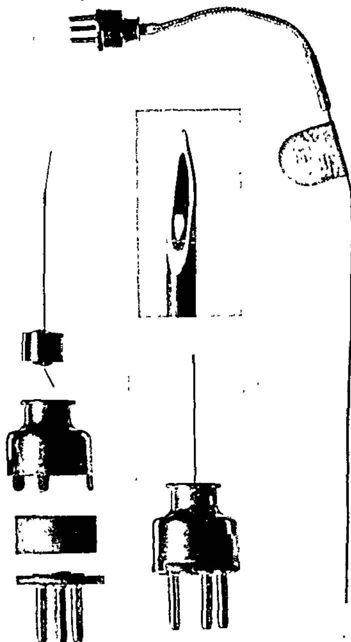


Fig. 13

The Assembly of the Coaxial Needle Electrode. A needle of the type used to record from the intrinsic laryngeal muscles is also shown.

With this as a basis, a study has been made, by means of action potential recording, of the *electrical activity* of muscles from the time of denervation up to complete re-innervation and functional recovery, both in experimental animals and in man (Weddell, 1943, *a* and *b*, 1944, 1945) The recordings are made with a carefully

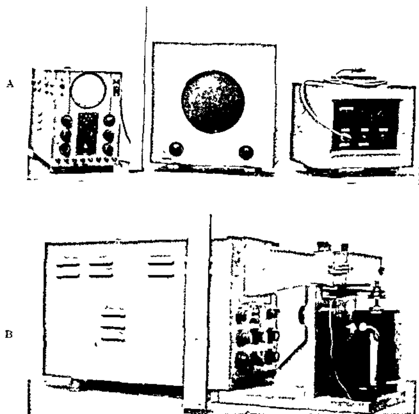


FIG 14

A Shows the Apparatus used for Clinical Electromyography
Note —It is all-mains driven, and very robust

B Shows a Camera attached to the Oscilloscope for making Permanent Records

screened coaxial hypodermic needle electrode coupled to a straight, all-mains, high-grade amplifier, which drives both a loud-speaker and cathode-ray oscilloscope Switching arrangements provide for graduated condenser shocks to be delivered down the needle for determining the exact position of the recording tip The oscilloscope is chiefly useful for obtaining permanent records, and in most cases it can be dispensed with (Fig. 14)

It has been found that, in man, no electrical activity can be

recorded from a normal relaxed voluntary muscle, and that it is possible to completely relax the majority of voluntary muscles With few exceptions, such as the scalene and laryngeal muscles, voluntary muscles can be relaxed completely, even the sacrospinalis muscles Motor unit action potentials, which appear only when the muscles contract, take the form of monophasic, diphasic, and rarely more complicated spikes, which vary in amplitude from 100 microvolts to 1 millivolt, and in duration from 5 to 10 milliseconds They are heard as low-pitched sounds in the loud-speaker, and vary in number and frequency with the strength of the contraction The concentric needle electrode has a normal useful recording range of 1 to 2 centimetres in respect of motor unit action potentials, which are the electrical counterpart of the simultaneous contraction of some hundreds of muscle fibres composing the motor unit

In man, provided the muscles under examination are at approximately blood temperature, it is found that spontaneous repetitive action potentials from fibrillating muscle fibres can be recorded from denervated voluntary muscles Fibrillation action potentials are of two types, those evoked by insertion of the electrode, which last a few seconds only, and those which are spontaneous and repeat rhythmically when the needle is motionless in the muscle They both take the form of monophasic or diphasic spikes, 1 to 2 milliseconds in duration and up to 100 microvolts in amplitude, repeating at variable rates between 2 and 10 per second, and heard as sharp clicks in the loud-speaker The time of onset of fibrillation activity in man is longer than in experimental animals In limb musculature the onset is from the 16th to the 18th day, in the facial muscles from the 12th to the 14th day, and in the sacrospinalis muscles from the 10th to the 12th day Fibrillation action potentials have been obtained from muscles denervated for eighteen years, although the number and frequency of the action potentials recorded in such cases is less than in muscles more recently denervated

Fibrillation action potentials can be obtained from partially denervated muscles, in cases where the number of motor units separated from their nerve supplies is minimal, the electrode has to be moved freely through the muscle before such action potentials are recorded Spontaneous repetitive motor unit action potentials uninfluenced by voluntary effort as well as fibrillation action potentials, are often recorded from cases of slowly progressive peripheral nerve interruption.

By raising the temperature of the circulating blood or warming the muscles under examination, the number and frequency of the fibrillation action potentials recorded from denervated voluntary muscle can be increased Prostigmin has a similar effect Cooling the muscles on the other hand, decreases the activity

It has been found that there is no relationship between the number and frequency of fibrillation action potentials and either the degree or rapidity of muscle atrophy, but muscles which have been receiving adequate physiotherapy, as judged by clinical examination,

fibrillate vigorously, whereas denervated muscles which have been excessively splinted fibrillate feebly

In cases of reversible ischæmic block, e g, Bell's palsy, motor unit action potentials can always be obtained on insertion of the needle electrode and it is usual to find a few repetitive motor unit action potentials which may or may not be under voluntary control On the other hand, fibrillation action potentials are absent or few in number and may be confined to discrete portions of the affected muscles

During the course of re-innervation, a decrease in the number of fibrillation action potentials recorded is observed before the return of motor unit activity In response to attempted contraction, motor

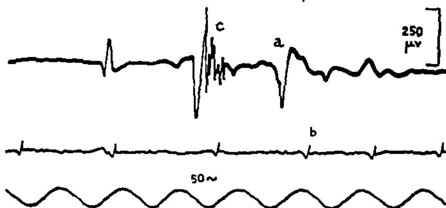


FIG 15

(a) Normal Motor Unit Action Potential
(b) Fibrillation Action Potentials
(c) Polyphasic Motor Unit Action Potential (Regeneration)

unit action potentials first appear close to the position of entry of the nerve into the muscle, and spread from this area Voluntary effort cannot be sustained by motor unit action potentials when they first appear following regeneration Prostigmin appears to have some beneficial effect in sustaining neuromuscular transmission in the early stages of re-innervation As motor unit activity increases, fibrillation activity rapidly decreases

The detection of small, very highly polyphasic motor unit action potentials is of definite value from the diagnostic point of view for, as far as is known at the moment, they appear only following nerve regeneration They are most numerous in the earliest stages of re-innervation, but may be obtained for over eighteen months after regeneration. They cause a characteristic rough sound in the loud-speaker

The interval between the first appearance of the motor unit action potentials and the commencement of detectable functional recovery can vary from two weeks to six months This depends to some extent on the particular muscles involved

Fig 15 shows action potentials typical of those obtained from normal, denervated and re-innervated muscles

From these observations it will be seen that use of electromyography as a diagnostic agent is of greater importance than heretofore. It can be used in addition to the familiar electrical reactions It has a number of advantages, among which is the detection of minimal degrees of lower motor neurone denervation In addition it is possible to record the electrical activity in denervated muscles, such as those of the larynx, in which the study of electrical reactions is out of the question, and it is of some interest to note that in a case labelled "recurrent laryngeal palsy of unknown ætiology" the diagnosis of arthritis of the crico-arytenoid joint was established by recording action potentials It is not suggested that electromyography should replace the determination of the electrical reactions by stimulation, but that electromyography is a more delicate method for gauging damage to the lower motor neurone, and is therefore valuable for the accurate assessment of peripheral nerve injuries and in the early stages of diseases affecting the lower motor neurone Moreover, the detection of fibrillation action potentials is a positive proof of denervation, which is not possible to obtain with other methods

GRAHAM WEDDELL.

Clinical Examination as a Whole

Having described the methods of examination and the details obtained in the examination of joints, certain points arise in the course of each clinical examination which must be mentioned

1 *Sweating*—Sweating is a constant occurrence in infective arthritis but seldom seen in osteoarthritis It is presumably associated with the katabolic nature of the disease, and certainly leads to loss of weight in many cases The odour, both in rheumatic fever and in infective arthritis is characteristic

2 *Obesity*—This is discussed in the chapter on the ætiology of osteoarthritis

3 *Loss of weight*—Loss of weight may be very marked It is a good indication of the activity of the process

4 *Blood pressure*—The blood pressure in infective arthritis is on the whole low and in osteoarthritis there is a tendency for it to be raised

The Problems that Complete Examination will solve

1 *Is there a physical basis for the patient's condition?*—Pain is such a constant symptom in the rheumatic syndromes that one of the problems in this branch is to find out whether it has a physical basis, as it is a prominent part of many "escape" syndromes The confusion which exists on the subject of the rheumatic diseases is due to an inability to pick out the cases due to physical change. If a physician tries to fit every patient complaining of pain into the physical pattern of rheumatism regardless of the presence or absence of signs, he will find himself confronted with such a conglomerate and confusing mass of material that he will despair of ever reducing

it to understandable shape. Careful physical examination acts lil a charm in such a dilemma, *order and pattern arising as the case* examined Pain produces some physical sign in about 90 per cen of cases This will show itself either as limitation of movemen tenderness, muscle atrophy, or interference with reflexes in tl locomotor system, or as cardiovascular and nervous signs an alteration in sensation in the general examination. The 10 per cen in which no physical signs are found belong largely to the grou known as osteoarthritis of the spine, which may produce severe pai without any physical signs whatever In addition, there is a *sma group* of cases complaining of universal pain with a few indeterminat signs *which will be discussed later* The physician's position is vastl strengthened if he knows whether or no a physical basis exists

2 *If a physical basis exists in what system does it lie?*—Thi *preliminary piece of information is indispensable. Time and agai* cases appear with a diagnosis of fibrositis in which the lesion does nc lie in the muscle or fibrous tissue Early diagnosis is a great help i these matters For instance, a case of pain in the left thigh involvin the area supplied by the femoral nerve had been disabled for a yeai The doctor missed the point that the lumbar spine was stiff and s failed to appreciate the likelihood of ankylosing spondylitis In si months with X-ray treatment he was back at his own job Thes points are mentioned to show how necessary full examination is i these conditions

Method of Recording the Examination

In making a report to the Joint Tuberculosis Council on th method of recording tuberculosis in the United States and Canad (Fletcher, 1931) the opinion was expressed that a printed form wa not so good or so useful as a blank sheet on which the physiciai could enter what he thought of value This view had to be re considered when trying to decide on the best way of recording chronic rheumatism, and the reasons are that the physical signs o rheumatism are so diverse and so far-flung, even in a *single* case that the whole body must be examined in order to arrive at a reason able conclusion, whereas pulmonary tuberculosis seems to behave ir a more *sequential and orderly manner and to have better understood* complications

It saves time to enter the ... as they are made One side of the sheet ... the other for physical signs ... Section A is with the patient supine Section B sitting up on the couch, Section C lying prone and Section D standing. Most of the locomotor findings are entered on the manikin and a space left at the bottom for descriptions of any special features

It is important to enter the clinical diagnosis at the time of the *examination This has value from two points of view* In the first place, it gives a good idea of the proportion of cases in which a conclusion cannot be reached In the second, it is good for the

soul, in that it provides a check on the number of cases in which the clinical conclusion is wrong! As experience is gained, the number of correct clinical conclusions slowly rises and this is good for the spirit!

The form in use at the Arthritis Clinic of the Royal Free Hospital is illustrated below (Fig. 16)

Fig. 16

X rays are invariably taken of the parts affected and a sedimentation rate and blood uric acid estimations are carried out. The Westergren technique is used for the sedimentation rate. In addition special examinations and blood phosphatase may be needed.

Some attempt will be made to show the more usual physical findings in each of the rheumatic syndromes.

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CHAPTER III

THE PHYSIOLOGY OF JOINTS

IN 1743 Hunter described the "circulus articuli vasculosus" and his description would differ little if rewritten to-day Bonn coined the term "synovial membrane" in 1763 Hueter's description of the synovial membrane as a connective tissue structure was written in 1864 Nerve fibrils in the membrane were described by Nicoladoni in 1871 and the lymphatics by Tillmans in 1876 A standard text-book on Applied Physiology contains no references either to joints or synovial fluid in its index This is a fair indication of how little progress has been made in recent years Few questions in this important branch of physiology are definitely settled but it is evident that further advance in the study of locomotor disorders waits largely on this type of knowledge

The Joint Cavity

In the embryo the remnant of mesenchyme from which the synovial membrane ultimately develops elaborates in its centre a liquid hyaloplasm The mesenchymal cells are then pushed outwards and become more dense eventually surrounding the joint cavity the perichondrium forming the capsule

It is now generally agreed that joint cavities are tissue spaces The idea that they could be regarded as serous cavities on all-fours with the pleura and peritoneum is now discarded

The synovial membrane is generally described as consisting of the inner layer, or intima and the outer fibrous layer Trabeculations may occur enclosing separate divisions which may be partially closed off from the main joint cavity Folds some of which occasionally become stuck together are numerous

The intima is firmly attached round the edges of the joint and may extend for a variable distance on to the articular cartilage Over tendons and ligaments it is usually adherent in other parts it is loose and can be lifted away In these regions appear many elastic fibres sometimes forming distinct elastic bands which prevent the membrane being nipped between the articular surfaces during movement The outer fibrous layer is attached to perichondrium and periosteum

Bauer, Ropes and Waine (1940) describe the *intimal cells* near the articular surface as large round or polygonal with coarsely granular cytoplasm, oval nuclei with a chromatin network in the nucleoplasm The lining cells may be in one or more layers and resemble endothelium or cuboidal epithelium but are not regular and a basement membrane has not been demonstrated Protoplasmic processes extend parallel to the surface and into the outer fibrous layer No 'goblet' cells have been demonstrated (Davies 1945) Synovial

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cells differ from fibroblasts in their ability to lyse fibrin and to secrete mucin The structure of the intima varies a great deal in different parts, and the subsynovial tissue has been used as a guide in the description of different types of synovial membrane. Three types have been described (Key, 1928) the "areolar" type, the "fibrous" type and the "adipose" type overlying the articular fat pads. Some areas are cellular and some cell-poor The cellular elements are separated from the cavity by collagen The outer layer shows smaller and fewer cells, with short processes and more elastic tissue *Villi project into the cavity from all areas* *The synovial membrane* is a vascular structure throughout its depth, being supplied by the circulus articuli vasculosis of Hunter This vascularity introduces difficulty in the evaluation of synovial fluid counts, as it is difficult to introduce a needle into the joint without extravasation of red blood cells Davies says that nitrogen is liberated early into the joints in decompression sickness and assumes that the capillaries are near the surface and permeable. Tillmans found two layers of lymphatics, a subintimal and a deeper layer This work has since been confirmed, as have the presence of nerve fibrils. From a study of these fibrils, Gerneck (1932) concluded that both vasomotor and sensory functions are subserved Some nerve endings are concerned with the appreciation of tension in joints It is important to remember that those nerves which supply the groups of muscles moving a joint, also supply the joint itself

The structure of *articular cartilage* is well known. Near the surface the cells are flat and lie parallel to the surface, but in the deeper layers they are irregular and in the deepest layers lie perpendicularly to the articular surface Somewhat the same arrangement may be seen in the skin, which is also adapted to bear pressure. Cells are more numerous in the superficial layers. Adult cartilage is avascular, and does not contain lymphatic or nervous tissue.

The histological structure of bursæ and their mesenchymal development suggest they have a close relationship to synovial tissue.

Nutrition and Growth of Cartilage

It has been shown that cartilage possesses spring and resilience if exposed to intermittent forces If these stresses become continuous it loses its power of recovery Its smooth surface reduces friction to a minimum, its resilient nature prevents jarring, and its lack of sensory nerve supply makes locomotion painless.

Nutrition has been ascribed to capsular and other blood supply, but even if this exists, it is probable that this supply is purely local General opinion is that *cartilage is mostly nourished by the synovial fluid* and it is known that the constitution of this fluid would be adequate for such a purpose Fisher has found that loose cartilaginous bodies in joints continue to grow He concluded that the layers of new cartilage were laid down by the synovial membrane

The *metabolism of cartilage* has been the subject of recent study—*Bywaters (1937) has shown that its respiration is low* but definite. The subject is highly technical, but it appears likely that metabolism

varies directly with the number of cells The metabolic activity of the matrix is about one-tenth that of connective tissue, but that of the cells is comparable to other tissues. Bywaters demonstrated a dehydrogenase in cartilage, but could make no guess as to its function, in view of its low respiration He also found the metabolism of fœtal epiphysial cartilage to be ten times that of adult cartilage and it also contained a higher glycogen content The cell content decreases with age Articular cartilage contains lactic acid, collagen, chondroitin sulphuric acid and calcium salts It is separated from the underlying vascular bone by a zone of calcified cartilage which increases in depth with age Elliot (1936) showed that in young animals cartilage divides by mitosis, but in later life this is replaced by amitotic division. Bowie *et al* (1941) confirmed the previous findings on the metabolism of cartilage They concluded that the [illegible] possibly [illegible] with age, [illegible] is loss is thought to contribute to the onset of osteoarthritis in older people

Davies states that at the articular surface lies a sheet of dead cells which is removed by the wear and tear of the joint These cells have not been taken into account in studies of the metabolism of cartilage

In any case the reparative powers of articular cartilage are small, especially over weight-bearing areas Lesions near the margin undergo repair by ingrowth of synovial tissue which becomes a poor sort of fibrous cartilage If the lesion goes through into the underlying bone, proliferation of tissue in the marrow spaces leads to repair in the same imperfect fashion

It appears that to keep viable articular cartilages must be kept in apposition with one another, and it will be remembered that de generation on one surface often leads to degeneration in its opposite fellow Cartilage is capable of resisting autolysis from enzymes in pathological joint exudates, but this mechanism may be limited in its effect and is not always present

Holmes *et al* (1935) have shown that synovial fluid has an appreciable anti-tryptic property, but not in all cases Some samples were able to inhibit the action of trypsin on casein, whilst others did not possess this property In those cases which showed it, it appeared that this was present quantitatively as well as qualitatively Further experiments demonstrating the action of trypsin on the protein of synovial fluid itself showed that 26 of 34 fluids possessed anti-tryptic property It was found that the anti-tryptic substances could be removed from the fluid by chloroform (as is the case with blood plasma)

If the fluid contains a large number of cells, and more especially if they are polymorphonuclear leucocytes, the anti-tryptic power is usually reduced It appears that plasma and synovial fluid contain roughly comparable amounts of anti-tryptic substance Presumably the presence of anti-tryptic properties in synovial fluid is to neutralise the ferments which are present in joint exudates.

The Silberbergs (1939) have demonstrated the effect of the

endocrine glands on growth of cartilage, particularly the anterior pituitary In young guinea-pigs administration of thyroid extract *also enhances the growth of hyaline cartilage*

It is not known how the necessary nutrition enters or leaves cartilage, but it is assumed that this occurs along the intercellular system of fibrils

With advancing years, the superficial strata undergo fibrillary degeneration It is rather curious, in view of what has been said, that Bennett and Bauer (1935) believed that proliferation in immature animals is no greater than in adults

In contrast with cartilage, *synovial membrane* is a highly vascular structure served with nerve fibrils and lymphatics, and with a high and undisputed regenerative power Key (1925) found that a nearly normal synovial membrane was re-formed sixty days after a partial synovectomy in rabbits As already mentioned, this is one of the arguments in favour of synovial membrane being a misnomer. *Synovial tissue is a better word*

The carriage of substances to and from the joint cavity has been studied

The principal route is via the capillary bed, and substances of low molecular weight pass easily both ways The lymphatics help in absorption from the joint cavity Substances with a high molecular weight have more difficulty Protein in the form of egg white and horse serum was injected into the knee joints of normal dogs, and precipitin tests were done on the blood, using the serum of rabbits immunised against the protein employed At rest the protein was detected fifteen to twenty minutes after injection and after exercise

stream by this route. Exercise and massage of muscles increase the rate of removal Exercise increases the rate of removal of serum albumin, but whether exercised or no the serum globulin is removed with great difficulty. This is attributed to the size of the molecule, and the conclusion is reached that the weight of molecule which can easily be removed from a joint lies between 72,000 and 175,000 This work may require confirmation

It seems possible that increased permeability of vessels may lead to an effusion rich in protein The increase in osmotic pressure would attract water, and if the proteins cannot be removed as fast as they are introduced the effusion would be maintained. Fibrosis of the membrane might lead to further difficulty in removal. The larger the effusion, however, the greater the surface exposed to physical forces and the greater the forces themselves.

Sugar appears in an effusion an hour or less after ingestion by mouth.

Synovial Fluid

Most of our recent information comes from Bauer, Ropes and Waine (1940) and Davies (1945)

Cell counts —A great deal of the work has been done on animals, mostly cattle The astragalo-tibial joint has been used, as 15 to 40 c c of fluid can be aspirated The average quantity from a human knee joint is 0 45 c c and quite often only 0 1 c c can be obtained

Coggeshall *et al* (1940) examined fluids from 29 knee joints at post mortem in cases which showed no evidence of articular disease The total number of nucleated cells varied from 13 to 180 cells per cu mm, the average being 63 cells per cu mm They found, as was thought before, that the synovial count bore little relationship to the blood count They concluded that red blood cells were not normal constituents of the synovial fluid The average differential cell count in the fluids was monocytes 47 9 per cent, clasmatocytes 10·1 per cent, unclassified phagocytes 4 9 per cent, lymphocytes 24 6 per cent., polymorphonuclear leucocytes 6 5 per cent, synovial cells 4 3 per cent, unclassified cells 2 2 per cent Eosinophils and basophils were not found in any of the 29 fluids The total count might have been higher if the joints had been in more active use up to the time of death. It appears that the high proportion of mononuclear cells is due to their action as phagocytes, removing debris from the joint It is, of course, possible that some of these cells may have been tissue histiocytes The normal synovial fluid total and differential count may, for the present, be regarded as the articular response to the minor traumata of everyday life, and it is of interest that the highest cell counts are observed in those cases showing wear and tear due to increasing age. This point is worth bearing in mind in connection with some of the arguments concerned with old age in other parts of this book As the joint space is now regarded as a tissue space and not a serous cavity, Bauer thinks that the cytology of synovial fluid may be analogous to that of tissue fluid

Normal synovial fluid is a pale yellow, very viscous fluid In ten examinations on patients with healthy knee joints the average pressure has been found to be − 3 cm of water (Fletcher, unpublished) These patients were supine and being operated on for other conditions. The lowest pressure was − 5 cm of water and the highest − 1 cm. of water They had all been in bed for 24 hours previously and the average time they had been under the anæsthetic was 20 minutes

Horiye (1924) found that the *specific gravity* of human synovial fluid ranged from 1 008 to 1 015 He also found the average *total solids* for post-mortem fluids to be 1 20 to 3 93 per cent Fisher found 4 4 per cent

[illegible] with a range of 51 to [illegible] If this is pre- [illegible] This factor appears to vary in different joints

The average *osmotic pressure* against Ringer-Locke solution is 365 mm of water for serum and 150 mm of water for cattle fluid This gives a difference of 215 mm. water By direct determination the figure is 250 mm water By calculation from the average serum albumin and globulin figures (75 4 for serum albumin and 19 5 for

serum globulin) the osmotic pressure is 384 mm of water Bauer *et al.* remark on the rough agreement of this figure with the value of 365 mm. water In the case of synovial fluid, however, the same calculation gives a figure of only 57 mm water (as opposed to the observed value of 150 mm) It seems likely that the difference must be due to *mucin*, and if so, its osmotic pressure (not yet directly determined) is calculated by these workers to be nine times as great as that of albumin (675 as compared with 75) This type of work is of the greatest value, as such a high osmotic pressure is likely to be of crucial importance

Protein values have mostly been calculated from cattle fluid. Not including the mucoprotein, the content is said to be 0·88 g. per 100 c c. in the serum and it is probable that the values in man are much the same Various workers found lymph protein to vary from 1·38 to 4 57 per cent , subcutaneous œdema fluid contains 0·25 g per 100 g. of water In a case of ascites secondary to carcinoma the ascitic fluid contained 4·36 g (Gilligan, Volk and Blumgart, 1934). There are marked variations in the albumin-globulin ratio, but the average in cattle fluid is 3 9, in the serum 1 1 The presence of serum proteins in lymph and tissue fluids is assumed for the moment to be due to slight capillary permeability. In this way the high albumin-globulin ratio in fluid would be explained on their relative molecular weights, allowing greater permeability to albumin

The question of mucin is of outstanding interest. It is responsible for the lubrication of the joint, for the high viscosity and the high osmotic pressure. In cattle its average concentration is 0·14 g. per 100 c c Including mucin the maximum total protein concentration of normal human fluid is said to be 3 23. The average mucin concentration is 0 85 per 100 c c Mucin contains a protein and a polysaccharide It is thought that the protein is a glyco-protein and that the polysaccharide (hyaluronic acid) is the same as that found in the vitreous humour, umbilical cord and group A hæmolytic streptococcus (see later)

Bauer confirms that normal synovial fluid contains no fibrinogen and does not clot. Occasionally a fluid does clot, presumably the fibrinogen comes from accidental extravasation of blood.

Non-electrolytes such as urea, uric acid and non-protein nitrogen occur in much the same concentration as in the serum This would [illegible]

[illegible]

inversely

Synovial fluid is said to contain the enzymes diastase and lipase with a highe[illegible] serum.

The pH [illegible]

Electroly[illegible] are present in higher concentration in the fluid than the serum of cattle, whilst sodium, potassium, calcium and magnesium are lower in fluid than serum Total inorganic phosphate is the same in both. This would be in

harmony with the Donnan equilibrium theory. The calcium concentration is high in the fluid Davies says that the concentration of calcium is proportionate to the mucin content and viscosity

Theories of Origin

Synovial fluid is probably an ultrafiltrate or dialysate of blood plasma, and Bauer *et al* (1940) confirm that this is their present view

As the mucin of the cartilage differs from that of the fluid, it is unlikely that the cartilage is the source of the synovial mucin The synovial cells may play some part as they secrete a mucin-like substance in tissue culture (Vaubel, quoted by Davies) The theory that joint spaces are tissue spaces suggests that the mucin may be the matrix of the space As both sulphate-free and sulphate-containing mucin exist in connective tissue, both should appear in the same proportion in the joint Davies says that there is no evidence for this

Functions of Synovial Fluid

It nourishes the articular cartilage and probably the superficial cells of the synovial membrane, particularly those villi without blood supply It is evident that the fluid acts as a *lubricant* for the joint surfaces The high osmotic pressure of mucin evidently retains fluid in the joint De Gara (1943) found bactericidal properties in synovial fluid, and thought these properties were related to the complement content as they were not destroyed by heating at 56° C for 30–60 minutes

Mucin is said to protect the joint surfaces from the action of acid metabolites and may do so, though the primary buffering action will be carried out by bicarbonate Some think it assists in keeping the articular surfaces in contact

Synovial Fluid in Articular Disorders

The present position with regard to staining of films of synovial fluid —There are two schools of thought on this matter, one advocates the method of intra-vitam staining and the other works with fixed smears Probably these different methods account for a good deal of the confusion which exists at the present time.

The exponents of the *intra-vitam method* claim that only by this technique can macrophages (clasmatocytes) be identified with certainty They also stress the marked differences that can be seen as to motility, phagocytosis, presence of specific granules, vacuoles and mitochondria with this method

The disadvantages are:

(1) Far more practice is required.
(2) The value of specific granulations in identifying a cell is uncertain

(3) It is not known at present whether synovial cells are phagocytic and whether they contain granules This may lead to inaccuracy in the macrophage and synovial counts.
(4) It is doubtful whether the additionally complicated classification provides any further important information on the easier method.
(5) The count has to be made at once

The *fixed-smear method* groups the cells under only four heads:

(1) Polymorphonuclear leucocytes
(2) Lymphocytes
(3) Monocytes and macrophages
(4) Synovial cells

It is easier because the groups are understood by everyone, the differential count can be done at any time and the slide is there for checking and comparison

It has the great disadvantage that information may be missed by grouping monocytes and macrophages together, and it *may be* less accurate

Anyone who wishes to do a number of synovial counts *should start with* the fixed-smear method and go on to the intra-vitam method later if he wishes

Synovial Fluid Values in Arthritis

When a joint effusion is present it is usually desirable and helpful to aspirate some of the fluid for examination This is a safe procedure provided it is done with all aseptic precautions Kling has made several thousand aspirations in all types of joint infection without any ill effect He has aspirated tuberculous joints amongst others

The examinations usually required are total and differential cell counts, estimation of total protein and sugar content.

Coggeshall *et al* (1941) studied the post-mortem fluids from patients dying of infection or œdema

	Fluids	*Amount*	*Cells*	*Neutrophils*	*Macrophagocytes*	*Lymphocytes*	*Synovial Cells*
		c c	per c mm	per cent	per cent	per cent	per cent
With *Infection*	20	1 40	1,022	34 5	49 0	16 5	1 4
With *Œdema*	18	10 70	32	22 1	51 9	23 9	1 6

They concluded from the above table that the quantity of synovial fluid was considerably increased in cases of œdema and that in these cases fewer nucleated cells were present than in normal fluid. Solids, viscosity, protein and mucin were all reduced In cases of infection the total nucleated cell counts and the absolute number of neutrophils

were considerably increased They concluded that the absolute number of neutrophils was a better guide to synovial tissue inflammation than the total nucleated count. This is a conclusion with which most people agree

The cytology of synovial fluid varies in the different types of arthritis There are few records, but Collins (1935) finds 10,000–20,000 cells per c mm in rheumatoid arthritis, and quotes 1,000–5,000 cells per c mm in rheumatic fever Gonococcal arthritis has a similar count to rheumatoid arthritis, in tuberculous arthritis there is a wide variety of findings and in infection with the hæmolytic streptococcus the cell counts are very high indeed All authors are not agreed

[illegible]

with blurred outlines and difficult to recognise In consequence a good deal of experience is required before an approximately correct count can be achieved.

A variety of cells not mentioned in the table are contained in normal synovial fluid such as clasmatocytes, synovial cells and unclassified phagocytes In pathological fluids some cells have been seen which could be classed as plasma cells and some as macrophages, but on the whole it was considered wiser not to introduce controversy by trying to name cells whose identity was in any doubt These cells have simply been placed under "other cells" The large proportion of monocytes (47 9 per cent) in normal fluid have not been found in pathological fluids in any disease

With the exception of two or three all the counts recorded here have been made with the "fixed-smear" method

The sugar content of pathological fluids varies with the blood sugar but also inversely with the cell content

The pH is said to be on the acid side in septic arthritis, as the pH rises the prognosis improves

Synovial fluid is being intensively studied in many places The present position is indefinite, but great advances will soon be made in this important subject

Collins (1935) quotes two cases of rheumatoid arthritis with findings in synovial fluid and blood

		Sugar	*Mgm NaCl*	*Per 100 c c Urea*	*Uric Acid*
CASE 1	61				
R A	Rt knee fluid	82	604	27	2 8
	Blood	85	600	30	2 8
CASE 2	48				
R A	Rt knee fluid	87	594	15	2 0
	Blood	85	597	18	2 0

Note —NaCl is the plasma level

EXAMINATION OF PATHOLOGICAL SYNOVIAL FLUIDS

	Normal	*Rheumatoid Arthritis (15 fluids)*	*Rheumatic Fever (4 fluids)*	*Bursitis (semi-membranosus) (1 fluid)*	*Old Still's Disease (2 fluids)*	*Synovitis (3 fluids)*
Leucocytes per cm	63	11,600	6,500	1,100	7,690	8,066
Polymorphonuclears per cent	6.5	55.7	56.0	22.0	63.0	84.6
Lymphocytes per cent	24.6	28.6	24.0	50.0	6.0	12.0
Monocytes per cent	47.9	10.0	10.0	28.0	6.0	.
Other cells per cent	21.0	6.0	10.0		25.0	3.4

	Focal Arthritis (2 fluids)	*Osteo-arthritis (8 fluids)*	*Intermittent Hydrarthrosis (5 fluids)*	*Gout (6 fluids)*
Leucocytes per cm	700	2,000	315	15,600 {max. 28,800; min. 2,400}
Polymorphonuclears per cent	34.0	28.4	55.0	74.0
Lymphocytes per cent	36.0	26.8	24.6	22.0
Monocytes per cent	20.0	34.0		.
Other cells per cent	10.0	10.8		

Results obtained in 46 fluids from patients suffering from different diseases

Hyaluronic Acid and Streptococcal Products

Hyaluronic acid, a component of mucin, is a mucopolysaccharide found by Meyer and Palmer (1936, *J Biol Chem*, **114,** 689) in vitreous humor, umbilical cord, joints and the capsules of Group A streptococci. It is hydrolysed by the enzyme hyaluronidase, which is identical with the "spreading factor" It seems from this that the enzyme may favour bacterial infection and that possibly hyaluronate may retard it. This is somewhat uncertain for it is known (Rogers, H J, 1945, *Biochem J*, **39,** 435) that in protein and peptone-free media the addition of hyaluronic acid increased the synthesis of hyaluronidase, the organisms being cultured at a certain optimal pH. Other organisms failed to show this quality. Group A streptococci (of which there are nearly forty varieties) show this characteristic well Thus capsular formation with a high hyaluronate content may indirectly increase the virulence of the organism. It will be noticed that this is the opposite line of argument to the one quoted above The matter is uncertain and McLean, O (1941, *J. Path Bact*, **53,** 13), concluded that hyaluronidase and *capsule formation went in inverse ratio. Lancefield was of opinion that the type specific M protein was more closely related to virulence* than capsule formation. Crowley (1944, *J Path. Bact.*, **56,** 27) found no relationship between virulence and hyaluronidase formation. Some authors have shown that the hyaluronate content of media

may determine proportionately the formation of hyaluronidase, and that this may aid defence Testicular hyaluronidase differs from the streptococcal enzyme, as the latter destroys the stimulating properties of hyaluronic acid, whilst the former does not. The breakdown products are not apparently known In any case other streptococcal products, hæmolysin, fibrinolysin, and leucocidin, have to be assessed and a tremendous amount of work has been done on them

The question of hyaluronic acid has been specially mentioned here because of its connection with mucin and the possibility that it may be concerned with the functions of synovial fluid and its osmotic pressure

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CHAPTER IV

THE APPLIED ANATOMY OF THE LOCOMOTOR SYSTEM

NO attempt is made in this section to describe the entire anatomy of the locomotor system. An adequate knowledge of the gross anatomy of the bones and muscles is possessed by most physicians, so these are not described, or only briefly mentioned. Attention is concentrated on those aspects not dealt with in detail in ordinary text-books, and this has entailed the allocation of a disproportionate amount of space to certain subjects, e.g., the vertebral column and joints. This is justified by their relative importance in lesions and derangements of the locomotor system.

Joints

Three classes of joints are described—fibrous, cartilaginous and synovial. In some the bones are directly united by a medium coextensive with the opposed surfaces and in others the interposed tissue becomes interrupted with the formation of a cavity.

I. Fibrous joints.—These allow no appreciable movement and the bones are united by fibrous tissue, as in the skull. In some the bond of connection is a short interosseous ligament, as in the inferior tibiofibular joint, and this is termed a syndesmosis.

II. Cartilaginous joints.—These permit limited movements and the surfaces are connected by cartilage or fibrocartilage. They may be primary or secondary in type.

(*a*) *Primary*.—The connecting medium is hyaline cartilage which usually becomes ossified, e.g., the junctions between the epiphyses and diaphyses of long bones.

(*b*) *Secondary*.—The opposed bony surfaces are covered by a thin layer of hyaline cartilage and united by a disc of fibrocartilage. The bones are also connected by ligaments, although an articular capsule is lacking, and rarely there is a rudimentary joint cavity. The joints between the vertebral bodies and the symphysis pubis are good examples of this type.

III. Synovial joints.—These are the commonest and the most elaborate in the body. They possess a joint cavity and are completely surrounded by a cuff of fibrous tissue, the capsular ligament (a term often abbreviated to "capsule" by clinicians), which is usually reinforced by additional ligaments and lined by a synovial membrane. [illegible] by articular cartilage. [illegible] o the bones in the vicinity [illegible] it shows several localised thickenings, and most synovial joints also possess extra- or intra-

...rate from the capsule.
...ile they do not impede
...abnormal excursions
They stretch if subjected to prolonged tension, but are protected by the powerful supporting activities of the muscles acting upon and inserted near the joint, in many the capsular ligament is actually reinforced by partial or complete tendinous insertions, or by expansions from near-by tendons The integrity of synovial joints is mainly dependent on the accessory ligamentous action of muscles and any diminution of their activities produces in time more or less serious derangements or even dislocation of the joint(s) concerned

The synovial membrane lines the capsular ligament, covers the non-articular parts of the bone within the capsule, and extends for a short distance over the margins of the articular cartilage It also ensheathes intracapsular structures such as tendons or discs, but not the latter if they are normally subjected to heavy pressure as, e g, the menisci in the knee It may form reduplications which project into the joint cavity and fill up potential spaces

processes which are covered by oval cells of connective-tissue type The villi are best seen in the neighbourhood of the articular margins and on the synovial membrane covering the intra-articular pads of fat found in the hip, knee, elbow, etc Some of the connective-tissue cells are phagocytic and by migration into the synovial fluid they may assist in removing the synovial and cartilaginous debris produced by wear and tear, while in pathological states they help in overcoming the results of infection or injury

Synovial membrane is a vascular structure and the vessels are especially numerous at the synovial reflection from the capsule to the bone, where they are derived from the circulus vasculosus surrounding the bony attachment of the capsular ligament The lymphatics form one fine network just beneath the free surface and another in the outer layer of the membrane, they drain into neighbouring lymph nodes There is also a fine plexus of delicate nerves in the membrane, with end-bulbs just beneath the free surface

Articular cartilage—The cartilage covering the articulating surfaces is usually hyaline, but may be white fibrocartilage The free surface is smooth and uncovered by perichondrium, but the marginal parts are slightly overlapped by the synovial membrane The deepest layer is calcified and firmly attached to the adjacent bone

It contains no vessels or nerves. The peripheral parts are nourished by capillaries in the overlying synovial membrane and the deepest layers receive nutrition from delicate vessels in the underlying bone The superficial parts of the central area have to obtain

their requirements from the synovial fluid and are less well nourished. Thus traumatic and degenerative changes are more liable to occur in the central areas, which in any case are usually subjected to more pressure and movement

Movements in synovial joints —The motion permitted is largely determined by the shape of the articulating surfaces and by the form and attachments of the ligaments Only gliding movements may be possible (plane joints), or the movement may be uniaxial (hinge and pivot joints), biaxial (condyloid and saddle joints), or multiaxial (ball-and-socket joints)

The range of movements in different joints is limited in various ways—by the shape of the articular surfaces, by the impingement or interlocking of parts of the articulating bones, by the approximation of soft parts, and by the restraining action of ligaments All these mechanisms are self-evident, but another factor, the accessory ligamentous action of muscles, is often inadequately appreciated. The balanced harmony of protagonist and antagonist activities ensures smooth muscular action, but the antagonists have another important function. Their action on joints is so adjusted that they seldom allow the ligaments to become strongly tensed, and they are responsible for preventing an abnormal and possibly harmful range of movement Naturally this activity may be impaired by muscular atony or paralysis, but if the muscles are functioning normally they do not allow articular excursions beyond the safety limits unless the force applied is sudden or excessive The mode of innervation provides evidence of the importance of this form of muscular activity. Hilton emphasised that joints and the muscles acting upon them are innervated from the same sources, and others have subsequently shown that the part of the capsule which is rendered taut by the contraction of certain protagonists is innervated by the nerve(s) supplying the [illegible] hip tenses the lower part of [illegible] the obturator nerve This [illegible] and stretching of the lower [illegible] contraction of these muscles, corresponding in intensity to the degree of the stimulus: more tension on the capsule induces a more powerful contraction in the adductors and in this way damage to the joint structures and ligaments is usually prevented unless the force applied is sudden and excessive

Varieties of synovial joints

(1) *Plane joints* have flat articulating surfaces and allow gliding movements, e g , the intercarpal and intertarsal joints.

(2) *Hinge joints* —The opposing surfaces are reciprocally curved and one surface may show a slight ridge which fits into a groove on the other The bones are united by strong collateral ligaments and movement occurs around the transverse axis, e g., the interphalangeal and humero-ulnar joints.

(3) *Pivot joints* —In this type a pivot-like process turns within

a ring, as in the superior radio-ulnar joint, or a ring rotates around a pivot, as in the articulation of the atlas with the odontoid process of the axis. Movement is uniaxial around a longitudinal axis

(4) *Condyloid joints*—The opposing surfaces are ovoid and moderately curved, a convex condyle being engaged in an elliptical concavity, e g , the wrist and metacarpophalangeal joints Movements occur about two axes arranged at right angles, flexion, extension adduction and abduction being permitted, but no active axial rotation

(5) *Saddle joints*—The articulating surfaces are reciprocally concavo convex and the movements are biaxial as in the preceding type The best example is the first carpometacarpal joint

(6) *Ball-and-socket joints*—In this type a globular surface fits into a cup-like cavity, e g , the hip and shoulder joints. The movements permitted are multiaxial and very free in every direction

Individual Joints

The more important joints in the appendicular skeleton are considered below Those in the axial part of the skeleton (vertebral, costovertebral and sacro-iliac) are discussed in the section on the vertebral column

THE SHOULDER JOINT is formed between the hemispherical humeral head and the less extensive, oval, shallow articular surface of the glenoid cavity Its capsule is lax and its ligaments weak and it depends very greatly on the support afforded by adjacent muscles and tendons Superiorly, however, it is protected by the acromion and coracoid processes and the broad coracohumeral ligament connecting them, while posteriorly it is buttressed by the base of the scapular spine

The glenoid cavity is slightly deepened by a cartilaginous rim, the *glenoidal labrum*

The lax *capsular ligament* is attached medially to the margin of the glenoid cavity just beyond the labrum, and laterally to the anatomical neck of the humerus, except on the inner side where it extends a little lower on to the humeral shaft It is reinforced

timately related to the capsule and partially blended with it The front part is also reinforced by slips from the tendons of Pectoralis major and Teres major The triceps tendon is separated from the inferior surface of the capsular ligament by the circumflex nerve and posterior humeral circumflex vessels, and this is not only the least protected part of the capsule but is also the part most liable to severe strain, particularly during forced abduction The tendon of the long head of Biceps arises within the joint from the supraglenoid tubercle and is enclosed in a sheath of synovial membrane as far as

the surgical neck of the humerus It arches above the humeral head and enters the bicipital groove after emerging through an opening in the capsule, being retained in the groove by an expansion from the pectoralis major tendon and by a band connecting the greater and lesser tuberosities—the *transverse humeral ligament*. By virtue of its attachments and relationships and its connection with the elastic biceps muscle it assists greatly in stabilising the humeral head and maintaining its apposition with the glenoid in all positions, but *every muscle mentioned assists in this process*

There are two and occasionally three openings in the capsular ligament. One is for the passage of the biceps tendon. Another is anteriorly where the bursa under the subscapularis tendon communicates with the joint A third inconstant opening may exist posteriorly if the bursa beneath the infraspinatous tendon communicates with the joint

The joint is innervated by the circumflex and suprascapular nerves and the blood supply is derived from the anterior and posterior humeral circumflex and suprascapular arteries

Movements in the shoulder region are the summation of movements at the shoulder joint and between the scapula and the chest wall The shoulder is of the ball-and-socket type and permits a greater range of movements than any other joint in the body, a freedom obtained at the expense of stability Abduction, adduction, flexion, extension, circumduction and rotation are all possible, besides a certain amount of gliding movement in every direction.

Johnston has pointed out that true abduction occurs in the plane of the scapula, which is inclined at approximately 30° to the coronal plane Abduction is easier in the scapular than in the coronal plane, and if the shoulder has to be immobilised for any reason the patient feels more comfortable if the limb is splinted in true abduction. If the scapular plane is used as the plane of reference for shoulder movements (instead of the coronal and paramedian planes) flexion and extension do not represent straight forward and backward movements, but occur at right angles to the scapular plane, e g., in flexion the humerus moves forwards and also somewhat medially across the front of the chest

Abduction is possible to 180° as a result of combined shoulder joint and scapular movements Up to 90° the motion mainly occurs in the joint and is produced by the Deltoid after the movement has *been initiated by the Supraspinatus, the scapula being almost immobilised* by the action of Trapezius and Serratus anterior to provide a fixed point for the deltoid contraction If the limb is being abducted in the coronal plane further abduction at the joint would be prevented by apposition of the acromion process and greater tuberosity, so automatically the humerus is rotated outwards to disengage the impinging bones In true abduction the bones almost "clear" one another, but the process is assisted by slight inward rotation of the humerus *Full abduction to 180° is mainly effected by the Trapezius* and Serratus anterior which rotate the scapula forwards so that the glenoid cavity faces upwards. Lockhart has demonstrated that

throughout
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Latissimus dorsi, assisted by the Teres major and Coracobrachialis Other muscles such as Subscapularis, Infraspinatus, etc, help in forced adduction

Flexion is produced by the anterior fibres of the Deltoid, the clavicular fibres of Pectoralis major, and the Coracobrachialis, assisted by the Biceps and Subscapularis The sternocostal part of Pectoralis major pulls the arm forwards from the fully extended position

In extension the posterior fibres of the Deltoid and the Teres major are principally concerned, but in forced movements from the flexed position the Latissimus dorsi, Infraspinatus, and long head of Triceps come into play, and until the arm reaches the neutral position between flexion and extension they are powerfully helped by the sternocostal fibres of Pectoralis major

Internal rotation is effected by Pectoralis major, the anterior fibres of the Deltoid, Latissimus dorsi, Subscapularis and Teres major, and external rotation by the posterior fibres of the Deltoid, Infraspinatus and Teres minor

THE ELBOW JOINT —The elbow joint is of the hinge variety, and is closely associated with the superior radio-ulnar articulation which acts as a pivot to permit pronation and supination of the forearm. The head of the radius is common to both joints, its upper concave

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and the trochlear notch of the ulna

The elbow possesses a capsular ligament and strong medial and lateral ligaments

The *capsular ligament* is fused at the sides with the collateral ligaments and elsewhere it constitutes the anterior and posterior ligaments The *anterior ligament* is attached above around the

the trochlea, the margins of the olecranon fossa and the capitulum, and to the back of the lateral epicondyle, and below to the margins of the olecranon process and to the annular ligament The *medial ligament* is fan-shaped and passes from just below the medial epicondyle to the adjacent margins of the coronoid and olecranon processes The *lateral ligament* is a strong band connecting the external epicondyle and the annular ligament

The synovial membrane lines the capsular ligament and covers the areas of bone within the capsule as far as the articular margins, including the coronoid, radial and olecranon fossæ. It also lines the deep surface of the annular ligament Behind it projects between

the radius and ulna as a narrow crescentic fold which conta
variable amount of fat between its layers There are other small
of fat underlying the synovial membrane in the olecranon, cor
and radial fossæ which become enlarged in lipoma arborescens
synovitis bulging is most evident at the sides of the triceps te
because the posterior ligament is the weakest and most lax pa
the capsular ligament.

The blood supply is derived from the free anastomosis bet
branches of the brachial, radial, ulnar and posterior interos
arteries, and the joint is innervated by twigs from the ulnar, m
and musculocutaneous nerves

Relations—The Brachialis lies in front of the joint, the T
and Anconeus behind, the common origin of the flexor m
medially, and the Supinator and common origin of the exte
laterally The ulnar nerve as it lies in the groove behind the m
epicondyle is in direct contact with the medial ligament, an
radial nerve lies close to the anterolateral aspect of the joint
passes downwards across the lateral epicondyle between the Brac
and Brachioradialis The median nerve and brachial vessel
separated from the joint by the Brachialis

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the latter chiefly by the Triceps and Anconeus

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that the radial head is so closely bound to the ulna by the an
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quite "true," so that when tended and supinat
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THE WRIST JOINT—The wrist joint is of the condyloid type
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the radius and its styloid process and to the front of the lower en

the ulna and the articular disc, below it is fixed to the adjacent carpal bones, some fibres being continued to the capitate The *posterior ligament* is weaker and has practically the same attachments as the anterior, but on the dorsal aspects of the bones The *medial ligament* extends from the ulnar styloid to the triquetral and pisiform bones and the *lateral ligament* connects the radial styloid to the scaphoid and trapezium

The synovial cavity does not communicate with the distal radio-ulnar joint or the synovial spaces in the carpus

The blood supply comes from the anterior interosseous artery, the carpal branches of the radial, ulnar and metacarpal arteries, and some recurrent vessels from the deep palmar arch The anterior and posterior interosseous nerves supply filaments to the joint

Relations —In front the tendons of Flexor digitorum profundus and Flexor pollicis longus and their synovial sheaths are in contact with the anterior ligament The median nerve is separated from the joint by the superficial and deep flexor tendons of the fingers and the ulnar artery and nerve by these tendons and the flexor retinaculum Behind are the extensor tendons of the wrist and fingers enclosed in their synovial sheaths The terminal parts of the anterior and posterior interosseous nerves lie respectively in front of and behind the joint, and the radial artery winds posteriorly between the lateral ligament and the tendons of Abductor pollicis longus and Extensor pollicis brevis

Movements —Flexion, extension, adduction, abduction and circumduction may all be performed actively, and passively slight gliding and rotatory movements are possible

The chief muscles producing these movements are flexion by Flexor carpi ulnaris and Flexor carpi radialis, assisted by the long flexors of the fingers and Palmaris longus, extension by the Extensores carpi radialis longus et brevis and Extensor carpi ulnaris, assisted by the long extensors of the fingers and thumb, adduction by Flexor and Extensor carpi ulnaris and abduction by the Extensores carpi radialis longus et brevis and Flexor carpi radialis Circumduction is produced by the consecutive contractions of the above muscles

THE INTERCARPAL JOINTS —These are of the plane variety and the bones are united by short anterior, posterior, medial, lateral and interosseous ligaments The flexor and extensor retinacula of the wrist act as accessory ligaments

The movements between individual bones in the proximal and distal rows of the carpus are limited The range is greater in the *mid-carpal* joint formed between the two rows This joint has a complex line On the lateral side the gently curved distal surface of the scaphoid is opposed to the trapezium and trapezoid on the medial side the rounded head of the capitate and the proximal angle of the hamate fit into the concavity formed by the triquetral, lunate and scaphoid bones

The *synovial membrane* of the intercarpal joints is extensive The main part corresponds to the mid-carpal joint, and two short prolongations extend upwards between the triquetral and lunate and lunate

the radius and ulna as a narrow crescentic fold which contains a variable amount of fat between its layers There are other small pads of fat underlying the synovial membrane in the olecranon, coronoid and radial fossæ which become enlarged in lipoma arborescens. In synovitis bulging is most evident at the sides of the triceps tendon because the posterior ligament is the weakest and most lax part of the capsular ligament

The blood supply is derived from the free anastomosis between branches of the brachial, radial, ulnar and posterior interosseous arteries and the joint is innervated by twigs from the ulnar, median and musculocutaneous nerves

Relations.—The Brachialis lies in front of the joint, the Triceps and Anconeus behind, the common origin of the flexor muscles medially, and the Supinator and common origin of the extensors laterally The ulnar nerve as it lies in the groove behind the medial epicondyle is in direct contact with the medial ligament, and the radial nerve lies close to the anterolateral aspect of the joint as it passes downwards across the lateral epicondyle between the Brachialis and Brachioradialis The median nerve and brachial vessels are separated from the joint by the Brachialis

Movements consist of flexion and extension, the former being mainly produced by the Biceps, Brachialis and Brachioradialis, and the latter chiefly by the Triceps and Anconeus

The trochlea of the humerus and the trochlear notch of the ulna form a hinge, whereas the joint between the capitulum and radial head would be of the ball-and-socket type were it not for the fact that the radial head is so closely bound to the ulna by the annular ligament that it moves along with it The hinge surfaces are not quite "true," so that when the forearm is extended and supinated it [illegible] with the arm This so-called "carrying angle" [illegible] 167° [illegible] faces

The elbow is [illegible] of its articular surfaces, its powerful collateral ligaments, and the support afforded by adjacent muscles and tendons, but it is liable to suffer severe mechanical shocks in falls on the outstretched hand, etc, which may overtax its stability An intact olecranon prevents *forward displacement, but anteriorly and laterally the joint is unprotected* by any bony buttresses so that backward and lateral dislocations are more common.

THE WRIST JOINT.—The wrist joint is of the condyloid type and is formed between the radius and articular disc above and the scaphoid, lunate and triquetral bones below. It possesses a capsular ligament and medial and lateral ligaments

As in the elbow joint the *capsular ligament* blends at the sides with the collateral ligaments and the parts in front and behind are known [illegible] posterior radiocarpal ligaments The *anterior* [illegible] end of [illegible] l of

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THE WRIST JOINT —The wrist joint is of the condyloid type and is formed between the radius and articular disc above and the scaphoid, lunate and triquetral bones below. It possesses a capsular ligament and medial and lateral ligaments

As in the elbow joint the *capsular ligament* blends at the sides with the collateral ligaments and the parts in front and behind are known as the anterior and posterior radiocarpal ligaments. The *anterior ligament* is attached above to the anterior margin of the distal end of the radius and its styloid process and to the front of the lower end of

are supplied by the median nerve, possibly supplemented in the case of the thumb by a contribution from the radial nerve. The interphalangeal joints of the ring finger are innervated by the median and ulnar nerves, and those of the little finger by the ulnar nerve alone

Movements —At the metacarpophalangeal joints flexion, extension, adduction, abduction and circumduction are possible, but only flexion [illegible]

the rounded head of the femur with the cup-shaped acetabulum The femoral head is completely covered by articular cartilage except over the small pit for the attachment of the ligamentum teres The cartilage lining the acetabulum forms a broad ring, incomplete at the acetabular notch and over the floor of the fossa A fibrocartilaginous ring, the *acetabular labrum*, is attached around the circumference and serves both to deepen the acetabulum and reduce the diameter of its inlet, the part bridging the acetabular notch is called the *transverse ligament*

The *capsular ligament* is strong and dense Above it is attached to the acetabular labrum and the bone beyond it Below it surrounds the femoral neck, and anteriorly it is attached along the trochanteric line and posteriorly about a half inch above the trochanteric crest, the deeper fibres are reflected upwards as longitudinal bands (retinacula) on the neck as far as the head, and these contain small vessels which help to nourish the adjacent bone The capsular ligament is thickest above and in front where most resistance is required and relatively thin and loose below The weakest points are postero-laterally and anteriorly (between the ilio- and pubofemoral ligaments) and so dislocations, or the extension of synovial infections, are most likely to occur through these areas

Three ligaments reinforce the capsule—iliofemoral, pubofemoral and ischiofemoral

The iliofemoral ligament is Y-shaped and is the strongest ligament in the body The stem is attached above to the anterior inferior iliac spine and the diverging limbs below to the upper and lower parts of the trochanteric line

The pubofemoral ligament strengthens the infero-medial part of the capsule, being attached medially to the superior pubic and iliopubic rami and blending laterally with the capsule and iliofemoral ligament

The ischiofemoral ligament lies posteriorly and stretches between the posterior acetabular margin and the postero-superior parts of the capsule

The ligament of the head (*lig teres*) is attached to a small pit a little below and behind the centre of the femoral articular surface, and to the margins of the acetabular notch and the transverse ligament It is ensheathed by synovial membrane and carries small vessels and nerves to the femoral head

The synovial membrane lines the capsular ligament, except over one area deep to the iliofemoral ligament where the femoral head presses

and scaphoid bones, and three downwards between the four bones of the distal row. *The interosseous ligament on one or other side of the trapezoid is often absent and then a communication is established between the intercarpal and carpometacarpal synovial cavities.* The small joint between the pisiform and triquetral bones has a separate synovial membrane.

The *movements* consist of flexion and extension and a moderate amount of adduction and abduction. They always occur in association with corresponding movements of the wrist joint and so increase the range of hand movements.

CARPOMETACARPAL AND INTERMETACARPAL JOINTS.—The first carpometacarpal joint is of the saddle variety. It has a thick, but rather lax, capsular ligament and a separate synovial cavity. Flexion, extension, adduction, abduction and a slight degree of medial rotation are permitted, and a combination of flexion, adduction and medial rotation produces the movement of opposition of the thumb.

The other four carpometacarpal joints are of the plane type, as are the small articulations (intermetacarpal) between the contiguous *sides of the bases of the corresponding metacarpals. All the bones* are united by anterior, posterior and interosseous ligaments. There is a common synovial cavity which, as stated above, usually communicates with the intercarpal synovial cavity. The movements are limited to slight gliding, *the second and third metacarpal bones* are almost immovable, but the fourth and particularly the fifth are more movable.

Nerve supply.—The intercarpal, carpometacarpal and intermetacarpal joints are innervated by filaments from the anterior and posterior interosseous nerves and by the dorsal and deep branches of the ulnar nerve.

THE METACARPOPHALANGEAL AND INTERPHALANGEAL JOINTS.—The former are condyloid and the latter are hinge joints, but their ligaments are arranged in a similar fashion.

Each joint has a capsular ligament which is thickest in front and is strengthened on each side by a narrow collateral ligament. The capsules are deficient posteriorly and are replaced by expansions of *the extensor tendons.*

The palmar aspects of the capsular ligaments of the medial four metacarpophalangeal joints are united by flattened transverse bands —the deep transverse ligaments of the palm. The digital vessels and nerves and the lumbricals pass in front of these ligaments, the interossei tendons lie behind. The transverse ligaments and the digital slips of the palmar aponeurosis are united by short fibrous bands.

Nerve supply.—The nerve supply of these joints is variable. The first, second and third metacarpophalangeal joints are supplied by the radial and median nerves, the first chiefly by the radial and the second and third mainly by the median. The fourth is supplied by the median and ulnar nerves and the fifth by the ulnar nerve *alone.*

The interphalangeal joints of the thumb, index and middle fingers

the iliofemoral ligament and the tension induced in the flexor muscles

Adduction results from the activity of the adductor muscles, assisted by the Gracilis and Pectineus. The movement is arrested by tension in the abductors and by the lateral part of the iliofemoral ligament.

Abduction is produced by the Glutei medius and minimus, the Tensor fasciæ latæ and the Sartorius. It is limited by the medial part of the iliofemoral ligament, the pubofemoral ligament, and the tension of the adductors

Internal rotation is effected by the Tensor fasciæ latæ and the anterior fibres of the Glutei medius and minimus, and external rotation by the obturator muscles, the Piriformis, the Quadratus femoris and the Gemelli, assisted by the Gluteus maximus, the Adductors and the Sartorius The former is checked by the ischiofemoral ligament and the latter by the outer limb of the iliofemoral ligament, assisted in each case by the antagonists of the prime movers

Examination of the hip joint.—Upsets in the normal anatomical relationships may easily be detected by simple tests

Intertrochanteric line —A line joining the highest parts of the greater trochanters normally passes through the centres of the acetabula.

Bryant's Triangle —With the body recumbent and the lower limbs parallel lines are drawn vertically downwards from the anterior superior iliac spines and others horizontally to meet them from the highest points of the greater trochanters The triangles are completed by connecting the first-named points Normally the triangles on the two sides should be practically equal and symmetrical In unilateral lesions they are not, but they may be if the lesions are bilateral, and then a clue may be provided by the distance between the trochanter and the vertical line dropped from the anterior spine, it is usually about two inches in the adult and if it is distinctly less it indicates some abnormality.

Nelaton's Line is drawn between the anterior superior iliac spine and the ischial tuberosity. Normally it passes through the highest

the deformities are symmetrical and bilateral

The above tests are useful in supplementing other methods of examination of the hip-joint regions

THE KNEE JOINT —In some lower animals there are three articulations in the knee region In man evidences of this arrangement persist, although the three parts are no longer separate There are two condyloid joints between the femur and tibia and an almost plane joint between the patella and femur As the condyloid surfaces are almost parallel, and as there are strong collateral ligaments (including the cruciates, which represent the collateral ligaments for the original pair of condyloid joints), the knee practically behaves as if it were a hinge joint.

against the capsule when the body is erect. It is reflected on to the femoral neck, which it covers up to the articular margin of the head. It ensheathes the ligament of the head and covers the small pad of fat occupying the non-articular area in the floor of the acetabulum. In about 10 per cent. there is a communication between the joint cavity and the bursa under the psoas tendon through a capsular opening located between the iliofemoral and pubofemoral ligaments.

Mechanics and movements.—The hip joint and the architecture of the constituent bones are admirably designed to combine strength and mobility. The almost hemispherical head and the deep acetabular cup together provide a very stable arrangement, which is enhanced by the immensely powerful ligaments and muscles surrounding the joint, and mathematicians have calculated that the trabecular patterns in the femur and hip girdle are perfectly arranged to provide the maximum resistance to stresses and strains.

Movements are multiaxial as in the shoulder joint. The angular movements of flexion, extension, adduction and abduction are partially effected by rotatory motion in the joint because of the length of the femoral neck and its inclination to the shaft.

Since this angle is altered in various conditions one may digress a little at this point. The vertical angle between the shaft and neck is usually about 130°, being somewhat greater in childhood. The neck is also angled forwards by about 12°—the declination angle. In coxa vara the vertical angle is reduced, sometimes to less than a right angle, and the declination angle is also reduced or obliterated, unless congenital dislocation co-exists, when it may be greatly increased. The great trochanter is raised and unduly prominent, the limb is adducted and rotated outwards, the limb is shortened, the pelvis becomes tilted, a compensatory scoliosis develops, and the unaccustomed stresses on the sacro-iliac and lower intervertebral joints may produce derangements. In the epiphysial type of coxa vara the lesion is facilitated because the direction of the epiphysial line alters. In early life it is almost horizontal, but owing to the growth of the neck it gradually becomes more vertical and has usually reached this stage by the age of 10–12, while the periosteum around the neck becomes thinner during adolescence. These alterations favour displacement, and even slight epiphysial slipping may injure the delicate vessels in the metaphysis, with consequent hyperæmia and decalcification. In coxa valga the vertical angle is increased and the limb is abducted and rotated outwards.

The principal muscles producing flexion are the Iliopsoas, Pectineus, Rectus femoris, Sartorius and the pubic part of the Adductor magnus. With the knee flexed the movement is limited by the apposition of the thigh and abdominal wall, but if the knee is extended it is arrested at an earlier stage by the tension of the hamstring group of muscles.

The chief extensor is the Gluteus maximus, the true antagonist of the Iliopsoas. The hamstrings and the ischial fibres of the Adductor magnus assist in maintaining extension and in producing the movement against strong resistance. Hyperextension is prevented by

the tibial condyles In transverse sections they are wedge-shaped, the thin edge being towards the centre, and thus they deepen the articular surfaces opposed to the femoral condyles The upper surfaces are concave and articulate with the femur, the lower surfaces are almost flat and cover approximately the peripheral two-thirds of the corresponding articular surface of the tibia The medial cartilage is semicircular in outline and its ends are attached to the anterior and posterior tibial intercondyloid areas in front of and behind the corresponding ends of the lateral cartilage, which is almost circular in form The outer margins of the cartilages are connected to the adjacent margins of the tibial condyles by short fibrous bands, the *coronary ligaments*, and a *transverse ligament* connects their anterior parts The fact that the medial cartilage and medial ligament are adherent but the lateral cartilage and ligament are discontinuous, has been mentioned already

The synovial membrane is the most extensive in the body It lines the capsular ligament and the parts of the bones within it as far as their articular margins Above and in front where the capsule is deficient it forms a pouch under the lower part of the Quadriceps, and this sac is drawn upwards by a small muscle, the Articularis genu which is inserted into it It is separated from the ligamentum patellæ by an infrapatellar pad of fat, and in this region forms two wing-like folds which project into the intervals between the opposing femoral and tibial condyles, the medial margins of these alar folds are united and are continued as a synovial strand, the infrapatellar fold to the front of the femoral intercondyloid notch In the fœtus

Relations —In front the Quadriceps femoris covers the joint, and the tendinous expansions from the Vastus medialis and Vastus lateralis which form the patellar retinacula, blend with the anteromedial and anterolateral parts of the capsular ligament The infrapatellar branch of the saphenous nerve unites with filaments from the medial, intermediate and lateral cutaneous nerves of the thigh to form the patellar plexus The tendons of the Sartorious, Gracilis, Semimembranosus and Semitendinosus lie posteromedially The biceps tendon with the lateral popliteal nerve on its inner side are posterolateral, and are separated from the popliteus tendon by the capsule Behind are the two heads of the Gastrocnemius, with the

the genicular branches of the popliteal and femoral arteries, the descending branch of the lateral femoral circumflex, and the recurrent tibial and circumflex fibular arteries

Both popliteal nerves and the femoral and obturator nerves supply articular branches to the knee joint

The bursæ around the knee are described on pp. 62–63.

perfectly adapted y the *interposition* llar and femoral articular surfaces are imperfectly adapted, and are only in partial contact with each other in various positions of the joint.

The various bones are connected by a capsular ligament, and by medial and lateral, cruciate posterior and patellar ligaments.

The capsular ligament is rather weak and is deficient in front, where it is replaced by the quadriceps tendon, the patella and the ligamentum patellæ It is strongly reinforced, however, by expansions from the various tendons around the joint and from the fascia lata, and by the other ligaments which blend with the capsule. Anteriorly it is united to the quadriceps tendon and the margins of the patella and ligamentum patellæ The deficiency above the patella allows free communication between the joint cavity and the suprapatellar bursa At the sides the capsule is attached above and below to the femoral and tibial condyles, and it blends indistinguishably with expansions from the quadriceps tendon known as the medial and lateral patellar retinacula The medial ligament is fused with the capsule, but the lateral is not, and the outer part of the capsule is blended with a strong fibrous contribution from the iliotibial tract of the fascia lata Posteriorly the capsule is attached above to the margins of the femoral condyles and posterior border of the intercondyloid notch, and below to the margins of the tibial condyles and the intercondylar area between them This part is reinforced by the *posterior oblique ligament* of the knee, which extends upwards and laterally from the tendon of the Semimembranosus to the lateral femoral condyle, and by an arched band of fibres, *the arcuate ligament*, which stretches between the lateral femoral condyle and the fibular styloid process

The medial ligament is a broad strap attached above to the medial femoral epicondyle and below to the medial tibial condyle and adjacent part of the tibial shaft It is intimately blended with the capsular ligament, receives expansions from the sartorius and semimembranosus tendons, and is closely attached to the adjacent rim of the medial semilunar cartilage *The lateral ligament* is rounded and extends from the lateral femoral epicondyle to the head of the fibula, it is not adherent to the lateral semilunar cartilage

There are two powerful *cruciate ligaments* in the middle of the joint. The anterior connects the anterior part of the tibial intercondylar area and the posterior part of the medial surface of the lateral femoral condyle The posterior stretches between the posterior intercondylar area of the tibia and the anterior part of the lateral surface of the medial femoral condyle The ligaments therefore cross each other in the form of an X

The ligamentum patellæ is the common tendon of insertion of the ... Quadriceps femoris and is a very strong ... tibial tubercle. The patella ... quadriceps tendon ... cover the peripheral parts of

the tibial condyles In transverse sections they are wedge-shaped, the thin edge being towards the centre, and thus they deepen the articular surfaces opposed to the femoral condyles The upper surfaces are concave and articulate with the femur, the lower surfaces are almost flat and cover approximately the peripheral two-thirds of the corresponding articular surface of the tibia The medial cartilage is semicircular in outline and its ends are attached to the anterior and posterior tibial intercondyloid areas in front of and behind the corresponding ends of the lateral cartilage, which is almost circular in form The outer margins of the cartilages are connected to the adjacent margins of the tibial condyles by short fibrous bands, the *coronary ligaments*, and a *transverse ligament* connects their anterior parts The fact that the medial cartilage and medial ligament are adherent but the lateral cartilage and ligament are discontinuous, has been mentioned already

The synovial membrane is the most extensive in the body It lines the capsular ligament and the parts of the bones within it as far as their articular margins Above and in front where the capsule is deficient it forms a pouch under the lower part of the Quadriceps, and this sac is drawn upwards by a small muscle, the Articularis genu which is inserted into it It is separated from the ligamentum patellæ by an infrapatellar pad of fat, and in this region forms two wing-like folds which project into the intervals between the opposing femoral and tibial condyles, the medial margins of these alar folds are united and are continued as a synovial strand, the infrapatellar fold to the front of the femoral intercondyloid notch In the fœtus the synovial membrane covers the semilunar cartilages, but later this investment disappears when the cartilages are subjected to pressure The intracapsular part of the tendon of Popliteus is separated from the lateral semilunar cartilage by a small synovial cul de-sac

Relations—In front the Quadriceps femoris covers the joint, and the tendinous expansions from the Vastus medialis and Vastus lateralis which form the patellar retinacula, blend with the anteromedial and anterolateral parts of the capsular ligament The infrapatellar branch of the saphenous nerve unites with filaments from the medial, intermediate and lateral cutaneous nerves of the thigh to form the patellar plexus The tendons of the Sartorious, Gracilis, Semimembranosus and Semitendinosus lie posteromedially The biceps tendon with the lateral popliteal nerve on its inner side are posterolateral, and are separated from the popliteus tendon by the capsule Behind are the two heads of the Gastrocnemius, with the popliteal artery and vein, the medial popliteal nerve and the popliteal lymph nodes lying between them

Around the knee there is a free arterial anastomosis formed by the genicular branches of the popliteal and femoral arteries, the descending branch of the lateral femoral circumflex, and the recurrent tibial and circumflex fibular arteries

Both popliteal nerves and the femoral and obturator nerves supply articular branches to the knee joint

The bursæ around the knee are described on pp 62–63.

Movements and mechanics—The femora are inclined inwards because the acetabula are further apart than the knees, but the tibiæ are almost vertical. The angles between them open outwards and average 172°, being somewhat greater in the female owing to the greater width of the pelvis The *tibiofemoral surfaces in each knee* are horizontal, however, because the medial femoral condyle projects further down than the lateral. If this relationship is upset, as it is in certain diseases, genu valgum or varum may result

The main *movements permitted are flexion and extension, and a*

Flexion and *extension take place round a transverse axis which* shifts backwards during flexion and forwards during extension owing to the varying anteroposterior curvatures of different parts of the femoral condyles The motion between the femoral condyles and

shape and direction *except anteriorly, where the surface* on the medial condyle curves moderately outwards The axis of the lateral condyle is straight and somewhat shorter than the curved axis of the medial condyle During movements the medial condyle must therefore travel slightly further than the lateral, and this *imparts* a slight degree of rotation At the end of extension there is a minor degree of inward rotation of the femur on the tibia, and when the movement is complete the slight depressions separating the tibial and patellar surfaces on each femoral condyle rest against the anterior parts of the corresponding semilunar cartilages. At the beginning of flexion the reverse motion occurs, the femur rotating outwards on the tibia. In the above description it is assumed that the foot is fixed on the ground. If the leg and foot are free the tibia rotates rather than the femur and moves in the opposite direction, i e slight outward rotation of the tibia at the end of extension and slight inward rotation at the initiation of flexion These rotations are essentially due to the differences between the lengths and axial directions of the femoral

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tibia inwards The rotation at the end of extension is facilitated during walking by the natural swing of the body. In stepping forwards one leg and the pelvis on that side move forwards When the foot is placed on the ground its movement is arrested, but the momentum carries the pelvis on that side a little further forwards, and as the tibia is more fixed than the femur the latter rotates slightly inwards.

When the body is erect the line of gravity passes in front of the *knees and tends to force them into hyperextension.* The super-

incumbent weight does increase to a minor extent the degree of extension produced by the Quadriceps femoris, and this is mainly permitted by a slight forward gliding movement and by compression of the anterior parts of the semilunar cartilages on the tibia Hyper-extension is prevented by the tension in the hamstring muscles, assisted by the posterior oblique, collateral and cruciate ligaments In the fully extended position the knee is so stable that it is said to be locked, and the position can be maintained for prolonged periods without fatigue

The knee is located between the longest and strongest levers in the body and its articular surfaces are ill adapted to each other, yet on account of its powerful ligaments and the great support provided by its associated muscles it possesses a high degree of stability. Great violence is necessary to produce the more serious lesions, such as dislocation, or rupture of the cruciate ligaments Injuries of the

changes of position is restricted by its attachment to the medial ligament The relatively exposed position of the synovial membrane and of parts of the femoral articular cartilage render them more liable to direct injury than corresponding structures in most other joints, and this is reflected in the relative frequency of synovitis, osteochondritis desiccans, etc The patella in protecting the knee may itself suffer injury, and as it is located in the tendon of a very powerful muscular group and is not accurately adapted to the opposing femoral surface it is liable to be snapped across by sudden, vigorous muscular action

Extension is produced by the Quadriceps femoris, assisted to a slight extent by the Tensor fasciæ latæ Hyperextension is prevented by tension in the hamstring muscles, and by the posterior oblique, cruciate and collateral ligaments, which become taut in full extension

Flexion results from contraction of the hamstring muscles (Biceps femoris, Semimembranosus and Semitendinosus), assisted by the Sartorius, Gracilis, Gastrocnemius and Plantaris The movement is arrested by contact of the calf and thigh It is usually possible through an angle of about 130°

Active rotation is most easily produced when the joint is semi-flexed Medial rotation is effected by the Popliteus, Semi-membranosus and Semitendinosus, assisted by the Sartorius and Gracilis, and lateral rotation by the Biceps femoris, the former is checked by the anterior cruciate ligament and the Biceps, and the latter by the collateral ligaments and the tension induced in the medial rotators

THE ANKLE JOINT —This joint is formed between the tibia, fibula and talus and it is of the hinge variety The body of the talus fits into a mortise formed by the lower end of the tibia, the two malleoli, and the inferior transverse tibiofibular ligament which stretches from the malleolar fossa of the fibula to the posterior margin of the tibial articular surface

As in all hinge joints the bones are connected by a capsular ligament, which is strongly reinforced at the sides by collateral ligaments

The capsular ligament surrounds the joint. It is attached proximally to the margins of the tibial and fibular articular surfaces and distally *around the articular surface of the talus, except in front,* where it extends to the dorsum of the neck of the bone. It is thinner behind than in front, and is strongly supplemented at each side by medial and lateral ligaments

The deltoid or medial ligament is triangular in shape, with its apex attached to the medial malleolus The fibres diverge from the apex and gain attachments to the navicular tuberosity, the "spring" ligament, the sustentaculum tali and the medial surface and tubercle of the talus It is closely related to the tendons of Tibialis posterior and Flexor digitorum longus as they pass obliquely downwards from the leg to the foot

The lateral ligament consists of three separate bands connecting the fibula, talus and calcaneum. The anterior talofibular ligament stretches between the anterior border of the lateral malleolus and the lateral aspect of the neck of the talus. The posterior talofibular ligament connects the lower part of the fibular malleolar fossa and the posterior tubercle of the talus The calcaneofibular *ligament* is a rounded cord extending from the tip of the lateral malleolus to a tubercle on the lateral surface of the calcaneum.

The synovial membrane lines the capsular ligament and covers the intracapsular area of the neck of the talus It forms a small cul-de-sac *between the lower ends of the tibia and fibula.*

Relations —Anteriorly from within out these are: the tendons of Tibialis anterior and Extensor hallucis longus, the anterior tibial vessels and nerve, [illegible]
Peroneus tertius [illegible]
of Tibialis posterior [illegible]
vessels and nerve, [illegible]
tendons of Peroneus longus and brevis are lodged in the groove behind the lateral malleolus

The arteries around the joint anastomose freely and form malleolar networks The medial malleolar anastomosis is formed by branches from *the* anterior and posterior *tibial, medial plantar, and dorsalis* pedis arteries. The lateral network is formed by branches from the posterior tibial, peroneal, lateral plantar and dorsalis pedis arteries

Both anterior and posterior tibial nerves supply filaments to the ankle

Movements.—The movements permitted are dorsiflexion and plantar flexion (extension) and the normal range of movement is about 90° The superior articular surface of the talus is broader in front than behind and in dorsiflexion the wider part is firmly embraced by the malleoli, but in plantar flexion the narrower posterior part glides into the tibiofibular mortise and slight degrees of side-to-side and rotatory movements are then possible.

The stability of the joint is dependent on the configuration of

the bones forming it, the strong collateral ligaments, and the many tendons surrounding the ankle. The human foot has often to resist forces tending to produce eversion and the deltoid ligament is specially strong to resist such stresses Indeed it is so strong that if disruption occurs the malleolus succumbs more often than the ligament Together with the various parts of the lateral ligament it resists displacement in every direction

Dorsiflexion is produced by the Tibialis anterior, assisted by the long extensors of the toes and Peroneus tertius It is limited by tension in the calf muscles and by the posterior fibres of the deltoid and lateral ligaments

Plantar flexion is mainly effected by the Gastrocnemius and Soleus assisted by Tibialis posterior, the long flexors of the toes, the Peroneus longus and brevis, and the Plantaris It is arrested by tension in the dorsiflexors and by the anterior fibres of the deltoid and lateral ligaments

The Foot

The foot is specially adapted in man to support and balance the body weight and to resist or neutralise mechanical shocks The chief modifications to this end are various arches develop which act as shock-absorbers, the calcaneum and talus become relatively large, the calf muscles become firmly attached to the calcaneum, and the foot becomes everted so that the surface originally directed inwards faces downwards and forms the sole As a result of these changes a broader surface for balancing and weight-bearing is provided, and the whole structure becomes resilient and capable of withstanding all ordinary stresses and strains

The foot is composed of many small bones closely connected by ligaments and tendons, supported by powerful muscles, and it is arched both longitudinally and transversely These arches are [illegible]

inner part is formed by the calcaneum, the talus, the navicular, the inner cuneiforms, and the three inner metatarsals, the keystone being the talus and the pillars resting on the calcaneum and the metatarsal heads The outer part is formed by the calcaneum, cuboid and two outer metatarsals The inner part is higher, touching the ground only at its extremities, while the outer part is almost flat and applied to the ground throughout most of its length The height varies racially individually, and at different ages The highly coloured races and particularly those who use no footwear, have less pronounced arches, and individuals with short, broad feet usually have higher arches than those with long narrow feet In early childhood the arches are less well marked than in the adult, and a variable degree of flattening is a common concomitant of senility

The transverse arch is less evident than the longitudinal and is

usually described as consisting of anterior and posterior parts. The ill-defined anterior part is constituted by the metatarsal heads and the more pronounced posterior part by the cuboid and cuneiforms and the adjacent bases of the metatarsals The first and fifth metatarsal heads are the main *points d'appui*, and if the weight is evenly distributed over all the heads pain may result from unaccustomed pressure on certain digital nerves and vessels lying between them The line of gravity, which passes in front of the ankle, is resolved into radiating components so that the weight is distributed over a triangle with its points represented by the calcaneal tuberosity and the first and fifth metatarsal heads. Actually, however, the other three metatarsal heads normally bear about half the weight, the distribution from the first to the fifth being in the ratio of 2, 1, 1, 1, 1. Occasionally the first metatarsal is abnormally short and bears less weight than usual, throwing more strain on the second metatarsal, and according to Morton this upset in weight-distribution is one cause of metatarsalgia.

The arches are maintained by the configuration of the bones, by their ligamentous attachments, and by the powerful support afforded by certain muscles and tendons. The ligaments aided by the muscles are capable of resisting most stresses, but if the strain is prolonged or excessive, if the line of gravity is altered by deformities such as genu valgum, if the muscles are weak, fatigued, or paralysed, or if the bones and ligaments are softened by disease, the arches may give way and the foot becomes flat. If the arch drops it follows that the medial border of the foot becomes elongated, the anterior part becomes somewhat abducted and everted, and the metatarsal heads tend to splay out. If the arch collapses completely the medial border of the foot becomes convex, the head of the talus being partially subluxated at the talonavicular joint

All the ligaments connecting the bones play a part in maintaining the arches, but some are more important than others. These are the "spring," long and short plantar and transverse metatarsal ligaments, while the plantar fascia, by virtue of its attachments to the extremities of the pillars, acts as a tie-beam preventing flattening of the longitudinal arch

The *"spring" or plantar calcaneonavicular ligament* stretches between *the anterior border of the sustentaculum tali* and the plantar surface of the navicular and is a mixture of white fibrous and yellow elastic fibres. Part of the deltoid ligament of the ankle is attached to its medial border, and the tendon of the Tibialis posterior becomes partially interwoven with its fibres It is the most important structure supporting the head of the talus, the keystone of the inner longitudinal arch

The *long plantar ligament* stretches from the posterior part of the plantar surface of the calcaneum to the cuboid and bases of the second, third and fourth metatarsal bones On its deep surface the *short plantar ligament* connects the calcaneum and cuboid Both support the calcaneocuboid joint and the outer part of the longitudinal arch. The *transverse metatarsal ligament* binds the metatarsal

heads together on their plantar aspects, and assisted by the plantar fascia it prevents splaying of the bones

Of the supporting muscles the Tibiales posterior* and anterior and the Peroneus longus are most important, but they are assisted by the long flexors of the toes and by the intrinsic plantar muscles of the foot The Tibialis posterior is mainly inserted into the navicular tuberosity and blends with the "spring" ligament, but it sends strong slips to every bone in the tarsus, except the talus, and also to the bases of the second, third and fourth metatarsal bones The Tibialis anterior is inserted into the inner sides of the first cuneiform and the base of the first metatarsal These muscles by their contraction invert and dorsiflex the foot, and by their postural tonus they protect the integrity of the longitudinal arch, for it has been emphasised that fibrous structures by themselves are incapable of resisting prolonged stress and strain

The long peroneal tendon crosses the outer surface of the calcaneum and then turns almost at right angles to run obliquely across the sole in a tunnel formed between the groove on the cuboid and the long plantar ligament It is inserted into the outer sides of the first cuneiform and the base of the first metatarsal When the muscle contracts the tendon becomes taut and not only acts as a sling for the middle of the longitudinal arch, but tends to approximate the cuboid and first metatarsal and cuneiform bones, so helping to maintain the posterior part of the transverse arch

Talipes—The deformity may consist of abnormal flexion or extension at the ankle joint (calcaneus or equinus), of abnormal inversion or eversion at the mid-tarsal joints (varus or valgus), or of exaggeration or flattening of the longitudinal arch (cavus or planus) Associated anomalies such as inward rotation of the tibia, absence of the fibula, "claw" toes, spina bifida,.etc , are common Usually the deformity is composite, e g , equino-cavo-varus In congenital equinovarus deformities there may be a thick fibrocartilaginous mass in the region of the "spring" ligament and the attachment of Tibialis posterior This so-called talonavicular capsule hinders correction of the deformity and operative removal of the mass may be necessary.

Bursæ

It has been calculated that there are at least 140 bursæ in the body (33 in each upper and 37 in each lower limb). Practically all those of clinical importance are situated near the major joints

Bursæ around Shoulder

(1) Subacromial (subdeltoid)—lies between the Deltoid, acromion process and coraco acromial ligament above and the Supraspinatus, capsular ligament and greater tuberosity below It does not communicate with the joint It is reputedly the commonest site of bursitis in the body, and the condition is frequently associated with lesions of the supraspinatus tendon

* Jones, R L (*Amer J. Anat*, 1941, LXVIII 1) questions the importance of Tibialis posterior as a supporting muscle and states that it is relaxed while the foot is sustaining maximum loads

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(4) Between the semimembranosus and semitendinosus tendons (inconstant)

Laterally there are two or three

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Posteriorly there are two.—One lies between each head of origin of the Gastrocnemius and the capsular ligament Both often communicate with the joint

The Vertebral Column

The central axis of the body, the spine or vertebral column

tion from a series of independent bony segments, poised accurately upon each other and firmly connected by a series of strong discs ligaments and muscles

At birth the column presents a general dorsal convexity, but later the cervical and lumbar regions become curved in the opposite direction when the child reaches the stage of holding its head up (3–4 months) and later of sitting upright (6–9 months) The dorsal convexities in the thoracic and sacral regions are primary curves because they exist in the fœtus and persist throughout life, whereas the cervical and lumbar ventral convexities are secondary and develop after birth These curves are due to slight differences in the anterior and posterior vertical depths of the vertebræ, and more especially of the intervertebral discs, in the various regions In later life when the discs become dehydrated and partially atrophied the secondary curves tend to disappear and the generalised senile kyphosis occasionally seen is a reversion towards the fœtal type of configuration

There are usually 33 vertebræ in the column 7 cervical 12 thoracic, 5 lumbar, 5 sacral and 4 coccygeal The cervical, thoracic and lumbar segments are separate and movable and are called *true vertebræ* The sacral and coccygeal segments are fused and are known as *false vertebræ* All conform to the same basic plan, although individual vertebræ show variations in different regions and species

A typical vertebra consists of two chief parts—the body situated anteriorly and the vertebral arch lying behind Between them they enclose a large opening, the vertebral foramen In the intact column the bodies with the interposed intervertebral discs form a continuous pillar, and the vertebral foramina constitute a canal for the reception and protection of the spinal cord

The bodies are more or less cylindrical segments consisting of a mass of spongy bone encased in a thin shell of compact bone The upper and lower surfaces are flattened and roughened for the attachment of the intervertebral discs Nutrient foramina exist on all

(2) *Subscapular*—between the subscapularis tendon and the articular capsule It communicates with the joint cavity

(3) *Infraspinatus*—inconstant—between tendon of muscle and capsule When present it may communicate with the joint.

(4) *Subcoracoid* — inconstant — between coracoid process and capsule

(5) *Acromial*—lies above the acromion on the summit of the shoulder

The other bursæ in the shoulder region are of minor clinical importance

BURSÆ AROUND ELBOW

Olecranon—a subcutaneous bursa overlying the olecranon and triceps tendon There may also be a bursa between the upper margin of the olecranon and deep to the triceps tendon.

Another bursa intervenes between the biceps tendon and the anterior part of the radial tuberosity

BURSÆ AROUND HIP

(1) *Subpsoas*—a large bursa separates the psoas tendon from the capsular ligament and the pubis It sometimes communicates with the joint cavity

(2) *Subgluteal* —There are usually six. Four lie deep to the Gluteus maximus, between it and (*a*) the greater trochanter (large and loculated), (*b*) the Vastus lateralis, (*c*) the ischial tuberosity; and (*d*) the outer lip of the iliac crest posteriorly. The last two are inconstant

One lies between the Gluteus medius and the antero-superior part of the greater trochanter, and another between Gluteus minimus and the medial part of the anterior surface of the greater trochanter

BURSÆ AROUND KNEE

There are four important bursæ anteriorly ·

(1) *Suprapatellar*—between the deep surface of Quadriceps femoris and the front of the lower end of the femur. This large bursa extends 2½–3 inches above the patella and communicates with *the joint cavity*

(2) *Prepatellar*—a subcutaneous bursa overlying the lower part of the patella and the upper half of the ligamentum patellæ

(3) *Subcutaneous infrapatellar*—overlying the tibial tubercle and the insertion of the ligamentum patellæ.

(4) *Deep infrapatellar*—between the ligamentum patellæ and the upper end of the tibia

Medially there are three or four ·

(1) Between the tibia and the tendons of Sartorius, Gracilis and Semitendinosus

(2) and (3) Between the semimembranosus tendon and the medial ligament, and between this tendon and the medial tibial condyle These may communicate

(4) Between the semimembranosus and semitendinosus tendons (inconstant)

Laterally there are two or three

(1) Between the biceps tendon and the lateral ligament.

(2) Between the popliteus tendon and the lateral ligament.

(3) The bursa separating the popliteus tendon and the lateral femoral condyle is usually part of the investment supplied by the synovial membrane of the knee, but occasionally it is separate

Posteriorly there are two—One lies between each head of *origin of the Gastrocnemius and the capsular ligament* Both often communicate with the joint

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surfaces, and there are one or more larger apertures on the posterior surface for the exit of veins

The vertebral arches are composed of a pair of pedicles and a pair of laminæ supporting seven processes—four articular, two transverse and one spinous In the arches and their processes the outer compact layer is thicker than in the vertebral bodies. The pedicles are the short, thick roots attached to the posterolateral parts of the bodies and the laminæ are plates which are directed inwards and backwards from the pedicles to meet and fuse in the mid-line posteriorly. The superior and inferior articular processes are situated above and below the junctions of the pedicles and laminæ, while the transverse processes *project* laterally *from the same situations* The *spinous* processes protrude backwards and downwards from the junction of the laminæ

The pedicles are somewhat constricted towards their centres and the concavities so formed above and below are called the vertebral notches. In the articulated column the adjacent notches form the intervertebral foramina which are bounded above and below by the pedicles, anteriorly by the corresponding intervertebral discs, and posteriorly by the articular processes and the joints between them *These foramina transmit the spinal nerves and vessels and are usually* proportionate in size to the emerging nerves. The lumbar intervertebral foramina, however, decrease in size from above down, although the corresponding nerves increase in calibre in the same direction, so that the largest nerves pass through the smallest foramina—actually the last lumbar nerves and the lumbosacral intervertebral foramina. To a lesser degree the same state of affairs exists in the cervical region, so that the sixth and seventh cervical nerves emerge through the smallest foramina Any swelling of the *contents of the foramina, or any injury or disease of the joints, discs,* or other structures bounding the apertures, may therefore cause pressure on the nerves, and from anatomical considerations it is not surprising that the lowest lumbar and cervical nerves should be most liable to pressure effects

Although all vertebræ are built up on the same general plan they exhibit certain group characteristics in each region; and at the junctions of the various regions transitional features appear which serve to adapt the vertebræ concerned to their neighbours. A number *of these group characteristics and transitional variations* influence both mobility and stability and these will be discussed subsequently under the appropriate headings.

The Vertebral Articulations

The true vertebræ articulate with one another by a series of cartilaginous joints between the vertebral bodies and a series of synovial joints between the articular processes

The b[illegible] discs
and by [illegible]
articular [illegible]
the vertebral arches and their processes are connected by supra-

spinous, interspinous and intertransverse ligaments, and by the ligamenta flava between the laminæ, the many powerful muscles attached to the various regions of the spine perform a vitally im-

oracic region receives
e ribs, particularly of
are attached to the
sternum by their costal cartilages Great weights and stresses are often borne by the spine, but its integrity is usually preserved by the shape and remarkable construction of the bodies and discs, by the arrangement of the articular processes, and by the powerful ligaments and muscles closely connected with it

The longitudinal ligaments are strong, strap-like bands extending along the anterior and posterior surfaces of the vertebral bodies The powerful *anterior* ligament is broadest below and is somewhat thicker and narrower opposite the bodies than opposite the discs It extends from the basi-occiput to the upper part of the front of the sacrum The weaker *posterior* ligament lies within the vertebral canal on the posterior surfaces of the bodies, and extends from the axis to the sacrum, its upper end is directly continuous with the membrana tectoria which prolongs the ligament to the basi-occiput In the thoracic and lumbar regi [illegible] row opposite the vertebral bodies and [illegible] its margins present a denticulated [illegible] gion its width is almost uniform throughout

Both ligaments consist of longitudinal fibres arranged in several layers which are firmly attached to the vertebral margins and discs, but only fixed loosely to the middle parts of the bodies The posterior ligaments are partially separated from the bodies by the basivertebral veins The deepest fibres extend between adjacent vertebræ, the intermediate layers extend between two to three vertebræ, and the superficial fibres stretch between four to five vertebræ

The intervertebral discs are interposed between the vertebral bodies from the axis to the sacrum and are the chief bonds of connection between them They are flattened discs corresponding in shape to the vertebral bodies between which they lie, and normally constitute just over one-fourth of the total length of the articulated column They are thickest in the lumbar region and thinnest in the middle third of the thoracic spine Relatively they contribute more to the lengths of the cervical and lumbar regions than they do to the thoracic region, which is therefore less pliant and mobile In the cervical and lumbar regions they are thicker in front than behind and are mainly responsible for the anterior convexities of these parts In the thoracic region they are of nearly uniform thickness and the anterior concavity is chiefly due to the shape of the vertebral bodies Their upper and lower surfaces are closely attached to the adjacent vertebral bodies by thin layers of hyaline cartilage, while anteriorly

and posteriorly they are adherent to the corresponding longitudinal ligaments

Each disc varies in consistence and structure in its central and peripheral parts, but the two merge almost imperceptibly into one another The central part consists of a pulpy substance, the *nucleus pulposus*, which contains the remains of the notochord and is particularly well developed in the lumbar discs. *It is highly elastic and* confined under tension by the surrounding parts, so that when the disc is sectioned the nucleus bulges above the cut surface. The circumferential part, the *annulus fibrosus*, is composed of concentric laminæ of fibrous tissue and fibrocartilage, and the fibres in adjacent layers are so arranged that they cross each other obliquely like the limbs of the letter X—a disposition specially adapted to resist the numerous torsion strains imposed on the spine. The annulus is thinner posteriorly and the fibres are less numerous. Further the posterior longitudinal ligament is usually weaker and narrower than the anterior ligament opposite the corresponding disc and thus provides less reinforcement for the annulus. These facts explain why herniation of the nucleus is more common posteriorly and posterolaterally Occasionally the annulus is poorly developed, or the posterior ligament may be unusually thin or even fenestrated, and these anomalies also predispose to extrusion of the nucleus pulposus posteriorly The nuclei may also become herniated into the vertebral bodies either because the intervening cartilage plates are poorly developed or because they are damaged by injury or disease.

Posterior prolapses of the disc were first described by Luschka in 1859 and rediscovered by Schmorl about seventy years later, while the latter also recognised that prolapses into the spongiosa of the vertebral bodies were not uncommon and were in fact present in 38 per cent of 3,000 spines examined (39 per cent. in males and 34·3 per cent in females) Between the ages of 18–59 disc herniations into the spongiosa were more common in males (40 per cent. in males and 20 per cent in females), but thereafter the position was practically reversed (23 per cent in males and 44 3 per cent. in females). This Schmorl attributed to the much greater activity of the male in earlier years, while the household and other burdens of the female often continue relatively unchanged throughout life. The majority occur opposite the nucleus pulposus and cause no subjective symptoms or signs, although the association with adolescent kyphosis is noteworthy, and they do reduce the efficiency of the discs as shock-absorbers

Posterior prolapses of disc substance into the vertebral canal were specially investigated by Andrae, an assistant of Schmorl's, and he found them in 15 2 per cent. of a series of 368 spines. They were [illegible] (18 7 per cent. in [illegible] nd 11·5 per cent. [illegible] was [illegible] enerative rather [illegible] herni [illegible] usually small [illegible] ulus [illegible] or longitudinal *ligament, or they m* [illegible] ough an o [illegible] li ment, or

present at its lateral margin Fortunately the majority are too small to produce pressure symptoms and they are commonest in the

At birth

r cent A gradual process of dehydration occurs with advancing age so that at eighteen the nucleus contains 80 per cent water and the annulus 72 per cent By the third decade the annulus content has fallen to 70 per cent, but thereafter it scarcely alters On the other hand the loss in the nucleus is steadily progressive, so that in old age the water content is approximately the same as in the annulus, i e. 68–70 per cent, and the disc appears homogeneous and remains flat when sectioned The desiccation lessens the elasticity of the discs and is accompanied by partial atrophy, occasional horizontal or radial fissuring, and patches of brown degeneration or calcification. In consequence they become less efficient as shock-absorbers and the flattening of the discs (particularly if the posterior parts are mainly involved) leads to narrowing of the corresponding intervertebral foramina and misalignment of the articular processes Thus the vertebral bodies are more liable to suffer injury, the misalignment of the articular processes favours the occurrence of strain and degenerative joint changes, and the narrowing of the intervertebral foramina may compress the contained nerves and vessels

The disc changes are degenerative in character and are evident at an earlier age than in any other body structures, not excluding the intima of the large arteries They are an expression of the paramount part played by the discs in the mechanics of the locomotor system. Upon them falls the main burden of absorbing and distributing the various pressure, tension and torsion strains to which the spine is so frequently subjected during life, and in man their load has been greatly increased by the assumption of the erect posture.

No nerve endings have been detected in the actual discs and they are avascular, obtaining their nutrition by the diffusion of lymph through tiny perforations in the contiguous vertebræ There is no layer of true compact bone over the central parts of the upper and lower surfaces of the vertebral bodies, the areas delimited by the original ring epiphyses The lamellæ of the spongy bone in these areas are closely set and are parallel to the surface, so forming a pseudo-compact layer, but it is more porous than ordinary compact bone. In later life the porosity tends to decrease in some cases and this may interfere with the nourishment of the adjacent disc and particularly of the nucleus pulposus

The vertebral arches articulate with each other by a series of plane synovial joints between the corresponding articular processes, and these are enveloped by thin, loose capsular ligaments attached around the margins of the articular facets These are most lax in the cervical region

In addition the arches are connected together by the ligamenta flava and by intertransverse, interspinous and supraspinous ligaments.

The *ligamenta flava* connect the laminæ and are attached to the lower and upper margins of adjoining vertebral arches. They extend backwards from the articular processes and become partially united in the mid-line posteriorly They are composed of yellow elastic tissue, are thickest in the lumbar region, resist hyperflexion of the spine, and by virtue of their elasticity assist in restoring the erect position following flexion. Occasionally they become greatly thickened as a result of injury or near-by disease, especially those in the lower lumbar region Such thickening is often found in association with posterior prolapses of the intervertebral discs and it is possible that an injury producing herniation may also injure the ligamenta flava.

The *supraspinous, interspinous and intertransverse ligaments* are less powerful and their positions and attachments are sufficiently indicated by their names In the neck the supraspinous ligament is represented by the *ligamentum nuchæ.*

The many musculo-tendinous masses attached to the vertebral column, such as the Longus capitis and Longus cervicis, the Scalene, Splenius and Semispinalis muscles, the Multifidus, and the very powerful Sacrospinalis and Psoas groups, besides many others, provide most active support to the various ligaments in maintaining the integrity of the vertebral column

The Mechanics and Movements of the Vertebral Column

Mechanically the vertebral column is a remarkable structure It permits a considerable range of mc [illegible]
the weight of the trunk, head and [illegible]
added stresses and strains imposc [illegible]
loads lifted or carried by the ind [illegible]
shock-absorber, it transmits its burdens through the pelvic girdle to the lower extremities, it acts as a post for the suspension of the thoracic cage, it provides an anchorage for many powerful muscles, and it affords protection to the delicate spinal cord It therefore combines static, dynamic and protective functions, and incidentally contains a large amount of the red marrow essential for erythrocyte formation

We have already studied how the sinuous column is built up of an alternating series of bony and fibrocartilaginous segments, intimately connected by strong ligaments and supported by powerful musculo-tendinous masses It is not a solid but an elastic system, which maintains a perfect state of dynamic equilibrium throughout the range of normal movements No more excellent arrangement could be devised to provide an adequately static column for support and muscle anchorage, yet one which is capable, when required, of considerable mobility The increasing size of the vertebral bodies from above down is related to the increasing weights and stresses borne by each successive unit, and the sacral vertebræ are fused together to form a solid, wedge-shaped base, cunningly arranged as the keystone in a bridge whose arches curve downwards towards the acetabula The intervertebral discs act as elastic buffers to absorb

and distribute the numerous mechanical shocks sustained by the column, whether they are due to pressure, torsion, or tension, and the alternating curves enhance the spring and resilience of the whole. Each curve is compensatory to its neighbour, so that the line of gravity intersects all four curves and the general line of the spine corresponds with the line of gravity, although each curve by itself produces a deflection in the anteroposterior direction. As a result there is a more or less even distribution of the body-weight around the line of gravity.

A study of the trabecular systems shows that the principal lamellæ are arranged vertically in the vertebral bodies and that other secondary lamellæ extend forwards in horizontal and oblique directions from the pedicles and articular processes The trabeculæ are so arranged that the body is particularly adapted to withstand vertical pressure, while the various processes are designed to resist the stresses imposed by the action of the attached muscles The internal architecture of the vertebræ therefore conforms to the law of functional adaptation

forces applied laterally, and once the force is removed it regains its normal shape on account of the natural spring and resilience of its discs and ligaments These properties are sometimes described as

are dependent on the highly elastic discs, which alter readily in shape owing to the fact that the pulpy nuclei shift backwards or forwards or from side to side within their annular fibrous capsules during flexion, extension and lateral bending movements, and the tension induced in the powerful ligaments limits undue mobility in every direction In life the ligamentous action is powerfully supplemented by the activities of the muscles attached to the vertebræ

Although there is only limited movement between any two vertebræ the sum of these movements confers a considerable range of mobility on the vertebral column as a whole Flexion, extension, lateral bending, rotation and circumduction are all possible, and, except for rotation, these movements are freer in the cervical and lumbar regions than in the thoracic part of the column. This is because the intervertebral discs are thicker in the cervical and lumbar areas, because the splinting effect produced by the thoracic cage is lacking, because the spinous processes are less closely apposed, and because the articular processes are arranged differently in the various regions

The arrangement of the articular processes influences both the mobility and stability of the vertebral column In the cervical region the articular facets are flat and oval and arranged in planes slanting from above downwards at an angle of about 45° This

configuration allows free mobility by the sacrifice of a certain degree of stability, and it is practically in the cervical region alone that a pure dislocation of the spine, without associated fracture, is possible. In the thoracic region the articular processes are more vertical in direction and the facets are arranged more in a coronal plane, an arrangement that limits mobility but increases stability; rotation, however, is slightly more free than in the other regions. In the lumbar region the superior articular facets are slightly concave and face inwards and backwards, while the inferior are slightly convex and face outwards and forwards But there is a gradual change in the direction of the facets Those of the upper lumbar vertebræ are arranged almost in the sagittal plane, whereas those at the lumbosacral junction are arranged nearly in the coronal plane. Variations of the above arrangement or asymmetry of the processes are not uncommon, and are a possible cause of disturbed function, strain and backache.

All movements are moderately free in the lumbar part of the column except rotation But slight rotation is possible in the lower lumbar region, and especially at the lumbosacral junction, because of the arrangement of the articular processes which approximates to the thoracic type. Many have asserted that this added movement is a source of weakness as flexibility and strength tend to be opposing virtues, but actually at the lumbosacral junction this is only partly true Owing to the tilt of the upper surface of the first sacral vertebra there is a constant tendency for the last lumbar vertebra to slide downwards and forwards when the trunk is erect, a contingency which is prevented by the disc, ligaments and muscles, and also by the arrangement of the articular processes which, being arranged almost in a coronal plane, impinge upon each other when the vertebra tends to slip forwards and act as buttresses preventing forward displacement (spondylolisthesis). Thus the loss of strength in one direction is more than compensated for by a gain in another.

A distinct angle exists between the lumbar spine and the sacrum due to the wedge shapes of the last lumbar and first sacral vertebral bodies and of the intervening disc. For British subjects this lumbosacral angle averages 137° in females and 140° in males The development of sacrovertebral angulation enables the trunk to be held erect despite the inclination of the sacrum. During the change from the quadrupedal to the bipedal position the sacrum underwent a relatively small degree of axial displacement compared with the rest of the vertebral column, and thus it is not placed vertically between the iliac bones but is set at a distinct tilt. The sacral obliquity varies in different individuals, but the erect position is maintained by appropriate variations in the lumbosacral angle and by the degree of lumbar convexity This may be maintained at the expense of stability, for any accentuation of the angulation means that the last lumbar vertebra rests on an increasingly sloping platform. On an average the upper surface of the first sacral vertebra is tilted at an angle of about 42° to the horizontal, but occasionally the sacrum lies almost horizontally and then the angle is very pronounced, even



FIG 17

Two Fifth Lumbar Vertebræ showing Interarticular Vertebral [illegible]
Defects and Spina Bifida



Fig 18

This specimen shows how the Inferior Articular Processes of the Fourth Lumbar Vertebra and the Superior Sacral Articular Processes act as Wedges, tending to disrupt the Vertebral Arch of a Defective Fifth Lumbar Vertebra

approaching a right angle, and there is a marked compensatory lumbar lordosis. This condition was described by Whitman as "prespondylolisthesis." Normally at the lumbosacral junction the bulk of the superincumbent weight is transmitted through the vertebral bodies and disc and only a small proportion through the articular processes, but any increase in the lumbosacral angulation leads to more unequal distribution of the weight, with the result that the junction becomes less efficient mechanically.

The facts already mentioned indicate that the lumbosacral junction is relatively unstable as compared with the other intervertebral joints, and there are still other factors to be considered It is the junction of mobile and rigid parts of the spine and such areas are potentially weak Any relaxation or destruction of the connecting ligaments and muscles due to injury, pregnancy, disuse, or disease interferes with stability still further, and abnormalities of posture or gait may subject it to undue strain. Certain congenital anomalies have a weakening effect, such as asymmetrical articular processes, abnormalities of the costotransverse processes (sacralisation and lumbarisation) and interarticular vertebral arch defects (Fig 17) The presence of these last-mentioned defects nullifies the buttress-like antiluxation action of the lumbosacral articular processes and favours the occurrence of strain and olisthesis. Moreover, as Capener has shown, the inferior articular processes of the fourth lumbar vertebra and the superior sacral articular processes act as wedges tending to disrupt the defective fifth lumbar vertebra, driving the anterior part of the vertebra (body, pedicles, transverse and superior articular processes) forwards and the posterior part (spinous process, laminæ and inferior articular processes) backwards (Fig 18) This explains the clinical paradox that in some cases of spondylolisthesis although the body is subluxated forwards the spinous process is abnormally prominent Incidentally arch defects due to injury or disease may occur at the same sites as these congenital anomalies and produce similar effects on the lumbosacral mechanics

lumbar vertebra in a normal spine (Fig 20)

Every muscle attached to the column has some action upon it,

muscles Extension is effected by the great sacrospinalis groups and

the splenius and semispinales muscles of both sides acting together. Rotation is produced by the Rotatores, Multifidus, Sternomastoid,



FIG 19

Ullmann's Line for determining Subluxation of Last Lumbar Vertebra.

Splenii, Longissimi and Semispinales Circumduction is limited and is caused by consecutive action of the various muscle groups.

The Costal Processes of the Vertebræ

Normally the costal processes of the primitive vertebral arches only give rise to separate ribs in the thoracic region. Extra ribs may develop in the cervical or lumbar regions, or anomalous developments

of the costal elements may occur in other regions, e g at the lumbo-sacral junction, and some of these are of clinical importance.



Fig 20

A Specimen showing that in rare instances Ullmann s Test may be too delicate, as his Line does not always pass anterior to the Last Lumbar Vertebra in a normal Spine

Diseases or injuries directly or indirectly involving the costovertebral articulations may also produce effects of practical importance

Supernumerary ribs —Extra ribs occasionally occur in the lower

cervical or upper lumbar regions due to the abnormal development of the corresponding costal processes, which normally are relatively small and form an intrinsic part of the corresponding transverse processes.

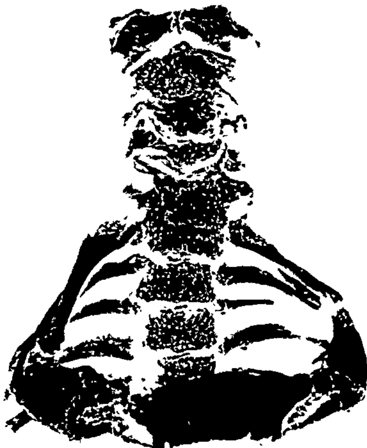


FIG. 21

A Specimen showing Bilateral Cervical Ribs and Congenital Fusion of the Fifth, Sixth and Seventh and Second and Third Cervical Vertebræ

The commonest and most important are those developing in connection with the last cervical vertebra (Fig 21) Keith has shown that there is always a rudimentary last cervical rib in the fœtus which usually disappears, but persists in 1–2 per cent. of cases. Not all cervical ribs cause symptoms and, although frequently bilateral, unilateral symptoms are common.

Many types of *cervical ribs* occur. Most are connected with the *last cervical vertebra and they are very seldom complete,* although

they often give attachment to the anterior and middle scalene muscles Usually the extra rib fails to reach the sternum and articulates or fuses with the first thoracic rib Often it is only partly osseous, the anterior end being deficient or represented by a fibrous band which is attached to the first rib The posterior bony portion varies greatly in size from case to case, and all grades may be found between an almost complete extra rib and a mere enlargement of the costal element of the seventh cervical transverse process with no true costovertebral joints Associated anomalies of the brachial plexus are common and Wood Jones states that if a seventh cervical rib is present the plexus is often prefixed, i e , the whole plexus has shifted one segment headwards and there is only a minor contribution from the first thoracic nerve Alternatively defective development of the first thoracic rib is apt to be accompanied by a post-fixed plexus, i e , the plexus has shifted caudally and receives large contributions from the first and second thoracic nerves

The trunks of the brachial plexus and the subclavian vessels arch outwards above the abnormal rib or the fibrous band connected with it, and irritation or stretching of these structures may produce sensory, motor, trophic and vascular disturbances The last may be due to irritation of sympathetic fibres in the lower trunk of the plexus rather than to pressure on the vessels, and in some cases the effects are produced by compression of the neurovascular bundle between the abnormally attached Scalenus anterior and Scalenus medius, these muscles become tense if the shoulder girdle droops and are converted into a variety of anatomical pincers When the shoulder girdle is high, as in childhood, symptoms are less prone to occur There is a progressive descent of the girdle which is not complete until about the age of twenty-five and symptoms are more [illegible] tomed work, [illegible] drooping of [illegible] isted before Sagging of the shoulder girdles for any reason may lead to irritation or stretching of the neurovascular bundle over a *normal* first rib and produce symptoms and signs similar to those often associated with cervical rib

The Costovertebral Joints

The majority of the ribs articulate with the vertebral column at two points—the heads with facets on the posterolateral parts of the vertebral bodies (costo-central joints), and the tubercles with facets on the anterior surfaces of the corresponding transverse processes (costo transverse joints) The costo-central joints are surrounded by capsular ligaments strengthened in front by radiating bands and except for the first and last three ribs, there are also short intra-articular ligaments binding the crest on the articular surface to the adjacent intervertebral disc The costo-transverse joints also have capsular ligaments, and superior, inferior and lateral costo-transverse ligaments which connect closely the rib neck and adjacent transverse process

Owing to the short and firm ligamentous attachments the range of movements at these joints is very limited, yet they are essential in the mechanism of respiration and any injury or disease affecting the articular or periarticular structures may result in poor chest expansion, while irritation of the adjacent intercostal nerves or sympathetic trunks may produce radiating pains or circulatory disturbances.

Sacralisation and Lumbarisation

The assumption of the erect posture necessitated skeletal modifications at the lumbosacral junction, and as finality in structure has not yet been attained developmental abnormalities are abundant. In the process of evolution the pelvis has migrated forwards, with consequent shortening of the lumbar region, but this migration is not exactly equal in every case, and the number of presacral vertebræ fluctuates between 23 and 25. These variations are usually due to the reciprocal gain or loss of a vertebra at the lumbosacral junction and often the process is incomplete, so that the vertebra gained by the sacral from the lumbar region (sacralisation), or vice versa (lumbarisation), fails to assume completely all the characters of its adopted region

The most striking anatomical feature in these conditions is the unusual appearance of one or both transverse processes of the last lumbar or first sacral vertebra These processes are really a combination of transverse and costal elements, and anomalous developments of the latter mainly account for the unusual appearance of the transitional vertebra. The abnormal costo-transverse processes may be large or small and symmetrical or asymmetrical. They may not reach the sacrum or ilium, but in other cases they articulate with the sacrum or even with the ilium on one or both sides. Sometimes there is unilateral or bilateral bony union between the enlarged processes and the sacrum, although the vertebral bodies and arches may remain partly or completely unfused

In most cases these anomalous processes cause no trouble, but they are capable of producing symptoms in various ways.

(1) If the process is not large enough to articulate with the sacrum or ilium, lateral bending movements may cause impingement, with consequent nipping of the intervening soft tissues; or an adventitious bursa may develop and become inflamed at intervals

(2) In unilateral cases the impingement of the process on the sacrum may provide a fulcrum for the spinal column, which then acts as a lever tending to prise apart the lumbosacral transitional vertebra from the sacrum, straining or tearing the connecting ligaments. Clearly the ligaments on the side opposite to the abnormal process will suffer most

(3) If the process articulates with the sacrum or ilium a so-called lumbosacral transverse articulation is formed. The cartilages of the joint are often thin and inefficient as shock-absorbers, thus lessening the resistance to traumatic insults. Repeated minor injuries initiate arthritic changes more readily under these circumstances.

(4) If the sacral auricular surface encroaches on the transitional process the corresponding sacro-iliac joint may also be more liable to arthritic changes

(5) Associated periarthritic changes may involve adjacent nerves, or ecchondroses or osteophytes around the margins of the abnormal joints may encroach on the adjoining intervertebral foramen and compress the contained nerves and vessels

(6) A number of important structures lie in close relationship to the lumbosacral junction If one or both last lumbar costo-transverse processes are enlarged any of these may be unduly stretched, especially [illegible]

subjective evidence of this unusual tension

The sacro-iliac joints intervene between the vertebral column and the hip girdle They are synovial in type and are formed between *the auricular surfaces of the sacrum and ilium* *These surfaces* are irregular, depressions on one corresponding with elevations on the other, and there are similar reciprocal sinuosities on the sacral and iliac tuberosities, which lie immediately behind the auricular surfaces The bones are connected by a capsular ligament and by anterior, interosseous and posterior sacro-iliac ligaments The *anterior ligament* is thin and reinforces the anterior part of the capsule The *interosseous ligament* consists of short fibrous bundles uniting the adjacent sacral and iliac tuberosities and is immensely strong. The *posterior ligament* connects the posterior superior iliac spine and the upper four transverse tubercles of the sacrum. The *sacrotuberous and sacrospinous ligaments* do not belong to the joint, but play an important rôle in its stability The former, very powerful, connects the posterior superior iliac spine, the three lowest transverse tubercles of the sacrum and the upper part of the coccyx to the inner margin of the ischial tuberosity; originally it was the proximal part of the long tendon of the Biceps femoris The latter, much less powerful, stretches between the sacrum and coccyx and the ischial spine, and is the fibrosed dorsal layer of the Coccygeus

[illegible]

fibrosis is the rule, myxomatous degeneration in the matrix may be *visible, areas of calcification may develop, the cancellous spaces* in the adjacent bone tend to become filled with fibrous tissue, and the *synovial cavity, originally complete, usually becomes partially or* completely bridged across by fibrous bands.

Sacro-iliac mobility varies in different individuals, in the two sexes, and at different ages, while pregnancy, trauma and disease also produce variations From birth till puberty there is a slight gradual decrease in mobility Thereafter in the male the ligaments become thicker and in the female they remain comparatively lax. Consequently in the male mobility decreases, but in the female it increases up to the age of twenty five, when the maximum degree

of mobility, apart from pregnancy, is attained. Thereafter in females diminution in mobility gradually occurs, although some persists in the majority even in advanced age, and if pregnancy occurs the ligamentous relaxation, especially marked about the time of parturition, leads to a temporary increase in the range of movement In males the decrease in mobility is slowly progressive from birth, and the majority of the joints in men over fifty have lost their diarthrodial characteristics and become amphiarthrodial, while ankylosis due to pathological changes becomes increasingly common

The gluteal, iliolumbar and lateral sacral arteries supply twigs to the joint, and it is innervated by filaments from both anterior and posterior primary rami of the first and second sacral nerves, from the superior gluteal nerve, and almost certainly by filaments from the lumbosacral nerve trunk The obturator nerve is in relation with the upper part of the articular capsule but apparently it does not supply the joint.

Relations —A number of important structures lie close to the joints. The antero-superior or *abdominal surface* is covered by the Iliopsoas, the femoral nerve is separated from it only by some fibres of the Iliacus, and the obturator nerve, lumbosacral trunk and iliolumbar artery are close relations. The antero-inferior or *pelvic surface* lies behind the upper part of the Piriformis and is crossed by the lumbosacral trunk and first sacral nerve The posterior divisions of the internal iliac vessels and their branches, and the internal iliac lymph glands, also lie near by The *dorsal surface* is covered by the Sacrospinalis and Gluteus maximus The posterior superior iliac spine is almost exactly opposite the centre of the joint, which is therefore at the level of the skin dimple overlying the spine The postero inferior end of the joint is at the level of the posterior inferior iliac spine and is superficial, being covered only by the skin, fascia and a few fibres of the Gluteus maximus

Mechanics —The wedge-shaped sacrum is the keystone in a bridge whose pillars curve downwards and outwards to the acetabula, and the sacro-iliac joints are the sites at which the weight is transferred from the vertebral column to the pelvic or hip girdle. This girdle is not a solid ring, but is interrupted at the two sacro-iliac joints and at the symphysis pubis These allow a certain amount of yielding and the cartilaginous inlays act as shock-absorbers.

The sacro-iliac joints have to support the superincumbent body-weight, plus any load lifted or carried by the individual, and they have to withstand mechanical shocks and thrusts produced, e g , by rapid spinal movements, jumping, running, etc. The load supported by each joint varies continually during walking and is influenced by posture and gait. Any postural upsets or limps, such as those produced by sitting or standing in strained positions, by paralysis, and by deformity or disease of the spine or lower limbs, lead to undue strain on one or other joint Ober has described one cause which is not generally known, he suggests that contracture of one ilio-tibial band of fascia lata produces a lateral pelvic tilt with consequent strain and irritation of the sacro-iliac joint(s).

Man's assumption of the erect posture has greatly increased the loads borne by the lower spinal and sacro-iliac articulations, and they have to function under less favourable mechanical conditions since these joints, originally designed for the quadrupedal position, have been adapted in the process of evolution to permit the assumption of the erect posture and bipedal progression Good as these adaptations are, some static and dynamic imperfections remain which predispose to strain and backache, and it is true to say that the enterprise of our forefathers is being visited on the children far

ident on the strength and
e of the articular surfaces
support than any others of
similar size and importance in the body The Gluteus maximus, Sacrospinalis, Psoas major and Piriformis all help, but the most important bonds of union are the interosseous ligaments, and stability is greatly influenced by the shape of the articular surfaces. These surfaces are arranged almost in the sagittal plane, but with a slight downwards, backwards and inwards inclination. The opposing surfaces, including those on the non-articular tubercles behind the joints, show reciprocal sinuosities which form an interlocking mechanism by virtue of the close apposition produced by the powerful connecting ligaments

The weight transmitted from the spine to the sacrum has two effects it tends to thrust the upper end of the sacrum downwards and forwards and to force the whole sacrum downwards and backwards between the innominate bones The downward and forward thrust merely produces a slight rotation of the sacrum about its horizontal axis through the middle segment, the upper end moving slightly downwards and forwards and the apex tilting in the opposite direction in the manner of a see-saw The former movement is soon checked by the interosseous sacro-iliac ligament and the latter by the sacrotuberous and sacrospinous ligaments To a lesser degree the arrangement of the articular surfaces assists the ligaments. The ventral margins of the lower parts of the sacral auricular surfaces are further apart than the dorsal (Fig 22) and any backward movement of the lower sacrum tends to prise the innominate bones apart, a

movement

Any tendency for the sacrum to be pushed downwards and backwards between the innominate bones also tends to drive them apart This is strongly resisted by the sacro-iliac and iliolumbar ligaments, while the ventral part of the pelvic girdle, connected by the ligaments of the symphysis pubis, acts as a tie-beam preserving the integrity of the girdle anteriorly

From what has been said it will be evident that any ligamentous relaxation, whether physiological as during pregnancy, or pathological



FIG. 22
Transverse Sections through the Upper, Middle and Lower Parts of the Sacro-iliac Joints The Reciprocal Sinuosities of the Articular Surfaces are visible Note that the ventral margins are slightly nearer than the dorsal in the highest section, while in the lowest the ventral margins are relatively much farther apart than the dorsal The sacrum pivots around the intermediate segment, but only a minor degree of "see-saw" motion is permitted, partly because of this arrangement of the articular surfaces, but mainly on account of the strength of the connecting ligaments

as the result of injury or disease, interferes with stability and favours sacro-iliac derangements

Posture

The maintenance of posture is intimately dependent on the intricate neuromuscular mechanism for controlling the postural activity of muscles

In man the maintenance of posture presents special problems, since the assumption of the fully erect position and orthograde locomotion is a relatively recent acquisition in the æons of evolutionary time. This position is a supreme achievement in adaptation and has necessitated skeletal, articular and muscular modifications. The body has to be supported on two limbs instead of four and the weight centre has changed position until it lies vertically above the feet. Clearly the problems of sustaining weight and maintaining posture are simpler in a quadruped with its four points of support, but basically the neuromuscular mechanism employed in preserving equilibrium is the same both in man and animals.

The skeletal and articular modifications in man are most evident in the lumbosacral region and feet and they are mentioned when considering

these parts. The muscular modifications mainly involve an increase in strength of the extensor (antigravity) muscles of the trunk and lower limbs These muscles—the Sacrospinales, Glutei, Quadriceps and calf muscles—possess a high degree of postural activity, but other muscles also play a part, for equilibrium is impossible without balanced muscular action This is clinically evident if one important group is paralysed, because alterations in posture and gait develop Thus if the Gluteus maximus is paralysed the body tends to fall forwards and so the centre of gravity is displaced backwards by compensatory over-activity of the other extensor groups, particularly those acting on the spine, and by increased arching or lordosis of the lumbar spine. In walking the body is jerked backwards each time the weight is borne on the affected limb and the next step with the sound limb is hurried If the Quadriceps femoris is paralysed the knee tends to flex and give way, since the integrity of the knee extensor mechanism is an essential factor both in standing and walking The patient may overcome his disability partially by various subterfuges He stands in such a way that the knee on the affected side is forced into mild hyperextension by the effect of the superincumbent weight, usually aided by backward pressure on the thigh by the patient's hand, and the thigh is held extended by compensatory over-activity of the hip extensors The knee is thus maintained in the locked position, but in time this is achieved at the expense of the ligaments normally restraining undue extension of the joint In walking the patient stoops forward and prevents the knee doubling up beneath him by firm manual pressure over the lower thigh, at the same time minimising the tendency to knee flexion by rotating the whole lower limb inwards or outwards

The chief protagonists and antagonists do not provide good substitutes for one another if muscle transplantation is required for paralysis of one or other group In the case of the lower limbs the postural activities of the muscles must also be considered before transplants are performed. Thus the quadriceps and hamstring groups not only produce opposite movements at the knee joint but show variation in their postural functions. In consequence the transplantation of the Biceps into the patella to replace the action of a paralysed Quadriceps is often a failure.

In the normal comfortable erect position the centre of gravity in man is at the level of the second sacral vertebra and the line of gravity, viewed from the side, runs downwards from the mastoid process, slightly behind the cervical vertebræ, through the cervicothoracic junction, slightly anterior to the thoracic vertebræ, through the thoraco-lumbar junction, slightly behind the lumbar vertebræ, through the antero-superior part of the sacro-iliac joints, directly behind the centre of the hip joints, and just in front of the knee and ankle joints Variations occur in different individuals, but consider-

interferes with normal weight transmission and the mechanisms for

absorbing and counteracting stresses and strains, alters the articular and muscular functions to a variable extent depending on the degree of abnormal posture, and may cause respiratory, neurological and circulatory disturbances. Someone has said that "a man stands as he feels" and poor posture by throwing abnormal stresses on joints,

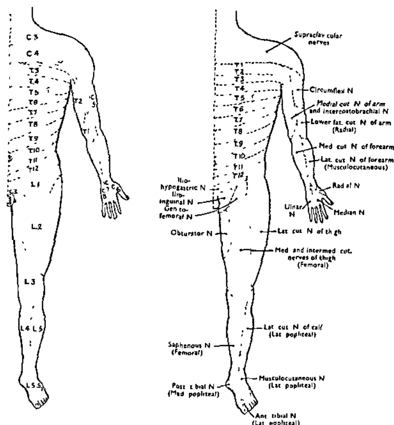


FIG 23

Diagrams showing the Cutaneous Areas supplied by the Spinal Nerves and by Individual Nerves (anterior aspect)

ligaments and muscles may evoke symptoms from the maladjusted structures or, if long continued, may lead to structural or degenerative changes in the bones and joints

Poor posture may be the result of carelessness, habit, fatigue, standir ... for long periods mental stress, ... litating illness, ... cles, or nerves *In pregnancy* and *obesity* the centre of gravity moves forwards on account of the increased weight anterior to the line of gravity, and this is counteracted by increased plantar flexion (extension) at the ankle and sometimes by the development of a slight lumbar lordosis owing to increased activity of the spinal

extensors A somewhat similar mechanism comes into play when a person wears high-heeled shoes, the foot accommodating itself by an increase in the normal plantar flexion at the ankle. If the heels are excessively high, however, the compensation may be incomplete at the ankles, the centre of gravity is displaced forwards, and the

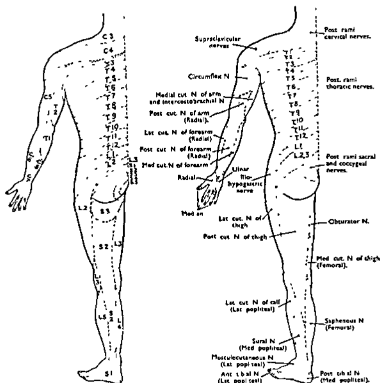


FIG 24
Diagrams showing the Cutaneous Areas supplied by the Spinal Nerves and by Individual Nerves (posterior aspect)

knees tend to become slightly flexed and the lumbar convexity is increased

The Distribution of the Spinal Nerves

The distribution is essentially segmental This is evident in the trunk, but is masked in the limbs. The diagrams reveal how the nerve-root areas in the limbs have been drawn outwards during the process of development (Figs 23 and 24) The figures showing the cutaneous nerve and segmental supplies are placed together to simplify comparison

The spinal nerves formed by the fusion of the anterior and posterior spinal nerve roots are short, and they divide almost

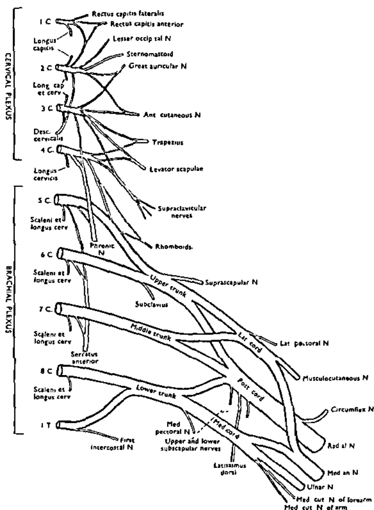


FIG 25

The Cervical and Brachial Plexuses (semi-diagrammatic).

CERVICAL PLEXUS

Muscular branches

To Rectus capitis lateralis—1 C
To Rectus capitis anterior—1, 2 C
To Longus capitis—1, 2 3 C
To Longus cervicis—2, 3, 4 C
To Sternomastoid—2, (3) C
To Trapezius—3, 4 C
To Levator scapulæ—3, 4 C
To Scalenus medius—3, 4 C
Phrenic nerve—3, 4, 5 C
Descendens cervicalis—2, 3 C

BRACHIAL PLEXUS

Certain branches are given off above the level of the clavicle and the remainder below it

Supraclavicular branches

To Rhomboids—5 C
To Serratus anterior—5, 6, 7 C
To Scaleni—5, 6, 7, 8 C
To Subclavius—5, 6 C
Suprascapular nerve—5, 6 C

The suprascapular nerve supplies the Supraspinatus and Infraspinatus

Infraclavicular branches —These are derived from the cords of the plexus

Medial Cord	Medial pectoral nerve—8 C, 1 T Medial root of median nerve—8 C, 1 T Ulnar nerve—(7), 8 C, 1 T Medial cutaneous nerve of arm—8 C, 1 T Medial cutaneous nerve of forearm—8 C, 1 T.
Lateral Cord	Lateral pectoral nerve—5, 6, 7 C Musculocutaneous nerve—5 6, 7 C Lateral root of Median nerve—6, 7 C
Posterior Cord	Upper subscapular nerve—5, 6 C. Lower subscapular nerve—5, 6 C Circumflex nerve—5, 6 C Nerve to Latissimus dorsi—6, 7, 8 C Radial nerve—5, 6, 7, 8 C, 1 T

Medial pectoral nerve—Pectoralis major and minor

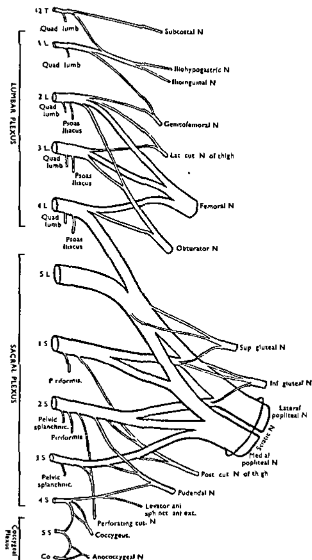


Fig 26

The Lumbar, Sacral and Coccygeal Plexuses (semi-diagrammatic).

LUMBAR PLEXUS

Femoral nerve—2, 3, 4 L
Obturator nerve—2, 3, 4 L
To Psoas minor—1 L
To Quadratus lumborum—12 T—3, (4) L.
To Psoas major and Iliacus—2, 3, 4 L
Iliohypogastric and ilioinguinal—1 L.
Genitofemoral—1, 2 L
Lateral cutaneous nerve of thigh—2, 3 L
Femoral nerve—Iliacus, Psoas major, Pectineus, Sartorius, Quadriceps femoris (Rectus femoris, Vastus medialis, Vastus intermedius and Vastus Lateralis), and Articularis genu
Obturator nerve—Gracilis (Pectineus), Adductor longus, Adductor brevis, part of Adductor magnus and Obturator externus
Genitofemoral nerve—genital branch supplies Cremaster.

SACRAL PLEXUS

Sciatic { Medial popliteal nerve—4, 5 L, 1, 2, 3 S
Sciatic { Lateral popliteal nerve—4, 5 L, 1, 2 S

To Piriformis—1, 2 S
To Levator ani, Coccygeus and Sphincter ani externus—4 S
Pudendal nerve—2, 3, 4 S

The sciatic nerve usually divides about the lower third of the thigh into medial and lateral popliteal branches

The medial popliteal nerve is continued onwards as the posterior tibial nerve and

The lateral popliteal nerve divides into the musculocutaneous and anterior tibial nerves The former supplies Peronei longus and brevis, and the latter Tibialis anterior, Extensor hallucis longus, Extensores digitorum longus and brevis, and Peroneus tertius.

Superior gluteal nerve—Gluteus medius, Gluteus minimus and Tensor fasciæ latæ
Inferior gluteal nerve—Gluteus maximus
Pudendal nerve—Sphincter ani externus and muscles in perineum.

immediately into anterior and posterior primary divisions which are responsible *for the innervation of the skin, muscles, bones and joints* of the trunk and extremities

The anterior primary divisions are generally larger than the

diagrams, and if the muscular distribution of any nerve is not indicated by its title, a separate list of the muscles supplied is also given. The posterior primary divisions do not form plexuses and they are distributed to the skin and muscles of the back.

In the penultimate table the actions of the principal muscles are summarised and the root values of their nerve supplies indicated, but it should be stated that the exact values are not accurately known in many cases

Ossification of Bones

Apart from the clavicle and the majority of the skull bones which are ossified in membrane, the others undergo intracartilaginous ossification. Certain rare diseases affect only membrane bones, while others affect only those preformed in cartilage.

Before ossification is complete, a long bone consists of the shaft *or diaphysis and two end pieces or epiphyses separated from the* shaft by plates of epiphyseal cartilage. The metaphysis is the junctional area between diaphysis and epiphysis and is important because

(1) *It is the site of most active bone growth.*
(2) It is highly vascular, but the vessels are virtually end arteries
(3) Ligaments and tendons are often attached near it, so that it may be subjected to mechanical stresses of various kinds.
(4) The vascular, actively-growing tissue is delicate and easily damaged.
(5) It may lie wholly or partly within the line of attachment of the capsular ligament and bone disease may invade the joint—or vice versa It is therefore essential to know the relative dispositions of the capsular attachments and the metaphyses These may be summarised for the more important bones:

Metaphysis partly or entirely intracapsular

Upper and lower ends of humerus.
Upper end of radius
Lower end of ulna.
Upper and lower ends of femur

Metaphysis extracapsular

Lower end of radius.
Upper end of ulna
Upper and lower ends of tibia.
Upper and lower ends of fibula

At the upper end of the ulna and lower end of the fibula the

capsular attachment is so near the epiphyseal line that clinically they may be regarded as comparable to the "partly intracapsular" class

Dates of Ossification

In the final table (facing p 96) atypical ossifications and unimportant or inconstant secondary centres are *not* mentioned The dates given are approximate, as the times vary within limits in different individuals, sexes, races—and text-books! The figures within brackets represent the dates when the part fuses with the main body or shaft, e g clavicle, sternal end (25)—this means the sternal end epiphysis fuses with the shaft by the age of 25 years.

"*Accessory*" *bones* are small, inconstant ossicles found in various parts of the body, and those occurring in the foot are much the most important The majority are bilateral, and in cases of doubt X-rays of both sides should be obtained. The most common sites are near the tuberosity of the navicular, the posterior surface of the talus (detached posterior tubercle), close to the tuberosity of the fifth metatarsal, and on the dorsum between the talus and navicular.

G A. G. MITCHELL

SUMMARY OF PRINCIPAL MUSCLE ACTIONS AND INNERVATIONS

JOINT OR PART MOVED	Flexion	Extension	Adduction	Abduction	Lateral Bending	Rotation Internal (I) Forward (F)* External (E) Backward (B)*	Elevation	Depression
VERTEBRAL COLUMN	Sternomastoid (Accessory N and 2-3 C) Longus cervicis (2-4 C) Scaleni (3-8 C) Iliopsoas (2-4 L) Rectus abd (6-12 T) Obliqui abd (5 T-1 L) Gluteus max (5 L, 1, 2 S) *All above acting bilaterally*	Splenius cervicis (Post rami lower C nerves) Semispinales (Post rami C and T nerves) Sacrospinalis (Post rami of L, T and C nerves) All above acting bilaterally			Muscles noted as producing flexion and extension when acting bilaterally produce lateral bending if they act unilaterally	Sternomastoid (Accessory N and 2-3 C) Splenii (Post rami C nerves) Longissimi (Post. rami C, T and L nerves) Multifidus and Rotatores (Post. rami of spinal nerves) Semispinales (Post rami C and T nerves)		
SCAPULA			Trapezius (Accessory N and 3-4 C) Rhomboids (5 C)	Serratus anterior (5-7 C) Pectoralis minor (8 C, 1 T)		Trapezius (F) (Accessory N and 3-4 C) Serratus anterior (F) (5-7 C) Levator scapulæ (B) (3-4 C) Rhomboids (B) (5 C) Pectoralis minor (B) (8 C, 1 T)	Trapezius (upper fibres) (Accessory N and 3-4 C) Levator scapulæ (3-4 C)	(Gravity) Serratus anterior (lower fibres) (5-7 C) Pectoralis minor (8 C, 1 T)
SHOULDER JOINT	Deltoid (ant part) (5-6 C) Pectoralis major (5-8 C, 1 T) Coracobrachialis (7 C) Biceps (5-6 C)	Deltoid (post. part) (5-6 C) Teres major (5-6 C) Latissimus dorsi (6-8 C)	(Gravity) Pectoralis major (5-8 C, 1 T) Latissimus dorsi (6-8 C) Teres major (5-6 C) Coracobrachialis (7 C)	Deltoid (5-6 C) Supraspinatus (5-6 C)		Pectoralis major (I) (5-8 C, 1 T) Deltoid (ant fibres) (I) (5-6 C) Latissimus dorsi (I) (6-8 C) Teres major (I) (5-6 C) Subscapularis (I) (5-6 C) Infraspinatus (E) (5-6 C) Teres minor (E) (5 C) Deltoid (post fibres) (E) (5-6 C)		

ELBOW JOINT	*Biceps (5–6 C)* Brachialis (5–7 C) Brachioradialis (5–6 C)	*Triceps (6–8 C)* Anconeus (7–8 C)						
RADIO-ULNAR JOINTS						Pronator teres (I) (6 C) Pronator quadratus (I) (6–7 C) Brachio-radialis (I—from full supination to mid prone position, and E full pronation to mid position (5–6 C) Supinator (E) (5–6 C) Biceps (E) (5–6 C)		
WRIST JOINT	Flexor carpi ulnaris (8 C, 1 T) Flexor carpi radialis (6 C) Flexors of fingers (7–8 C, 1 T) Palmaris longus (8 C)	Extensors carpi radialis longus et brevis (6–7 C) Extensor carpi ulnaris (7 C) Extensors of fingers (7 C)	Flexor carpi ulnaris (8 C, 1 T) Extensor carpi ulnaris (7 C)	Extensores carpi radialis longus et brevis (6–7 C) Flexor carpi radialis (6 C)				
METACARPO-PHALANGEAL JOINTS	Flexores digitorum sublimis et profundus (7–8 C, 1 T) Interossei (8 C, 1 T) Lumbricals (8 C, 1 T)	Extensor digitorum (7 C) Extensor indicis (index only) (7 C) Extensor digiti minimi (fifth finger only) (7 C)	Palmar interossei (8 C, 1 T) Long flexors of fingers (7–8 C, 1 T)	Dorsal interossei (8 C, 1 T) Long extensors of fingers (7 C)				
DIGITAL JOINTS	Flexor digitorum sublimis (*proximal joint*) (7–8 C, 1 T) Flexor digitorum profundus (proximal and distal joints) (7, 8 C, 1 T)	Interossei (8 C, 1 T) Lumbricals (8 C, 1 T)						
THUMB	Flexor pollicis brevis (proximal phalanx) (8 C, 1 T)	Extensor pollicis brevis (proximal phalanx) (7 C)	Adductor pollicis (8 C, 1 T)	Abductor pollicis longus (6–7 C) Abductor pollicis brevis (8 C, 1 T)		Opponens pollicis (I) (8 C, 1 T)		

* The terms forward and backward rotation are used only in reference to scapular movements. In forward rotation the scapula turns in such a way that its inferior angle moves forwards and outwards away from the mid line and in backward rotation the opposite motion occurs.

SUMMARY OF PRINCIPAL MUSCLE ACTIONS AND INNERVATIONS—*continued*

Joint or Part Moved	Flexion	Extension	Adduction	Abduction	Lateral Bending	Rotation Internal (I), External (E)	Elevation	Depression
Thumb	Flexor pollicis longus (proximal and distal phalanges) (8 C, 1 T)	Extensor pollicis longus (proximal and distal phalanges) (7 C)						
Hip Joint	Iliopsoas (2–4 L) Rectus femoris (2–4 L) Pectineus (2, 3 L) Sartorius (2, 3 L) Adductor magnus—pubic part (3, 4 L)	Gluteus maximus (5 L, 1, 2 S) Biceps femoris (5 L, 1–3 S) Semimembranosus (4, 5 L, 1, 2 S) Semitendinosus (4, 5 L, 1, 2 S) Adductor magnus—ischial part (4, 5 L)	Adductores magnus, longus, brevis (2–5 L) Gracilis (2–4 L) Pectineus (2, 3 L)	Gluteus medius (4, 5 L, 1 S) Gluteus minimus (4, 5 L, 1 S) Sartorius (2, 3 L) Tensor fasciæ latæ (4, 5 L, 1 S)		Glutei medius et minimus (I) (4, 5 L, 1 S) Tensor fasciæ latæ (I) (4, 5 L, 1 S) Obturator internus (E) (5 L, 1, 2 S) Obturator externus (E) (3, 4 L) Piriformis (E) (1, 2 S) Gluteus max (E) (5 L, 1, 2 S) Quadratus femoris (E) (4, 5 L, 1 S) Adductors (E) (2–5 L) *Sartorius* (*E*) (2, 3 L)		
Knee Joint	Biceps femoris (5 L, 1–3 S) Semimembranosus (4, 5 L, 1, 2 S) Semitendinosus (4, 5 L, 1, 2 S) Sartorius (2, 3 L) Gracilis (2–4 L) Gastrocnemius (1, 2 S)	Quadriceps femoris (2–4 L) Tensor fasciæ latæ (4, 5 L, 1 S)				Popliteus (I) (4, 5 L, 1 S) Semimembranosus and semitendinosus (I) (4, 5 L, 1, 2 S) Sartorius (I) (2, 3 L) Gracilis (I) (2–4 L) Biceps femoris (E) (5 L, 1–3 S)		

FOOT	Tibialis ant (4, 5 L, 1 S) Extensor hallucis longus (4, 5 L, 1 S) Extensor digitorum longus (4, 5 L, 1 S) Peroneus tertius (4, 5 L, 1 S)	Gastrocnemius (1, 2 S) Soleus (5 L, 1, 2 S) Tibialis posterior (5 L, 1 S) Flexor hallucis longus et flexor digitorum longus (5 L, 1, 2 S) Peronei longus et brevis (4, 5 L, 1 S)	Tibialis anterior (4, 5 L, 1 S) Tibialis posterior (5 L, 1 S)	Peronei longus et brevis (4, 5 L, 1 S) Extensor digitorum longus (4, 5 L, 1 S)			Tibialis ant —raises inner border (4, 5 L, 1 S) Tibialis post —raises inner border (5 L, 1 S) Peronei longus et brevis — raise outer border (4, 5 L, 1 S) Peroneus tertius—raises outer border (4, 5 L, 1 S)	
TOES	Flexor digitorum longus (5 L, 1 S) Flexor digitorum brevis (5 L, 1 S) Flexor digitorum accessorius (1 S) Flexor hallucis longus (5 L, 1, 2 S) Flexor hallucis brevis (5 L, 1 S) Flexor digiti minimi (1, 2 S) Interossei and lumbricals—first phalanges only (1, 2 S)	Extensor digitorum longus (4, 5 L, 1 S) Extensor digitorum brevis (4, 5 L, 1 S) Extensor hallucis longus (4, 5 L, 1 S) Interossei and lumbricals — middle and distal phalanges only (1, 2 S)	Plantar interossei (1 2 S) Adductor hallucis (great toe only) (1, 2 S)	Dorsal interossei (1 2 S) Abductor hallucis (great toe only) (5 L 1 S) Abductor digiti minimi (fifth toe only) (1, 2 S)				

Summary of Principal Muscle Actions and Innervations—*continued*

Joint or Part Moved	Flexion	Extension	Adduction	Abduction	Lateral Bending	Rotation Internal (I) External (E)	Elevation	Depression
Thumb	Flexor pollicis longus (proximal and distal phalanges) (8 C, 1 T)	Extensor pollicis longus (proximal and distal phalanges) (7 C)						
Hip Joint	Iliopsoas (2–4 L) Rectus femoris (2–4 L) Pectineus (2, 3 L) Sartorius (2, 3 L) Adductor magnus—pubic part (3, 4 L)	Gluteus maximus (5 L, 1, 2 S) Biceps femoris (5 L, 1–3 S) Semimembranosus (4, 5 L, 1, 2 S) Semitendinosus (4, 5 L, 1, 2 S) Adductor magnus—ischial part (4, 5 L)	Adductores magnus, longus, brevis (2–5 L) Gracilis (2–4 L) Pectineus (2, 3 L)	Gluteus medius (4, 5 L, 1 S) Gluteus minimus (4, 5 L, 1 S) Sartorius (2, 3 L) Tensor fasciæ latæ (4, 5 L, 1 S)		Glutei medius et minimus (I) (4, 5 L, 1 S) Tensor fasciæ latæ (I) (4, 5 L, 1 S) Obturator internus (E) (5 L, 1, 2 S) Obturator externus (E) (3, 4 L) Piriformis (E) (1, 2 S) Gluteus max (E) (5 L, 1, 2 S) Quadratus femoris (E) (4, 5 L, 1 S) Adductors (E) (2–5 L) Sartorius (E) (2, 3 L)		
Knee Joint	Biceps femoris (5 L, 1–3 S) Semimembranosus (4, 5 L, 1, 2 S) Semitendinosus (4, 5 L, 1, 2 S) Sartorius (2, 3 L) Gracilis (2–4 L) Gastrocnemius (1, 2 S)	Quadriceps femoris (2–4 L) Tensor fasciæ latæ (4, 5 L, 1 S)				*Popliteus* (I) (4, 5 L, 1 S) Semimembranosus and semitendinosus (I) (4, 5 L, 1, 2 S) Sartorius (I) (2, 3 L) Gracilis (I) (2–4 L) Biceps femoris (E) (5 L, 1–3 S)		

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s	18–20 Years	Remarks
		Occasionally body is ossified from 2 centres which fail to unite [illegible] vertebra) or develop unequally (wedge vertebra). Failure of fusion or non-appearance of arch centres produces various degrees of spina bifida. Occasionally 2 centres appear in one or both halves of the arch and if these fail to fuse the congenital type of interarticular vertebral (neural) arch defect results.
	Sternal end (25) Acromial end (25) (inconstant)	The clavicle shows evidence of ossification before any other bone—usually between the 35th–45th day.
		The spine is ossified by an extension from the body centre. Other secondary centres, additional to those shown, may appear about puberty. Any of the secondary centres may fail occasionally to fuse with the main part of the bone.
		The tuberosity and head centres fuse by the age of 6 and the combined epiphysis unites with the shaft about 20. The lower end centres (excluding one for med. epicondyle) fuse to form a composite epiphysis about 15–16 and this soon unites with the shaft.
		An inconstant centre may appear in the tuberosity about puberty and soon fuses with shaft.
		The usual scale-like upper epiphysis is sometimes larger and then forms a considerable part of the olecranon process.
		Each of the 2 – [illegible]
		The femoral neck is ossified by an extension from the shaft. The various epiphyses unite independently with the shaft.
		Occasionally there may be 2 or more centres
		The tubercle is formed by an extension from the upper epiphysis. It, and also the tip of the med. malleolus, may be ossified from small separate centres
		The lower centre appears first and fuses first—an exception to the usual rule that the centre appearing first joins at a later date.
		Post. extremity of calcaneum formed by flattened epiphysis

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CHAPTER V

THE INCIDENCE AND PREVALENCE OF ADULT RHEUMATISM

BEFORE discussing the incidence of any disease it is necessary to be clear what we mean by incidence. Many indices, some good, many misleading, are commonly used, and to the inexpert person it is often difficult to appreciate the different aspect each actually measures

Within a definite area such as England and Wales, for which the population in any given year can be very closely estimated, one measure of the incidence of a disease would be the ratio of the number of *new cases*, occurring within a given period (say a year), to the total population Since for some complaints, such as colds, influenza and bronchitis, the number of new cases would almost certainly involve counting several attacks to the same persons, this index is termed the *attack rate* and needs to be amplified by statistics giving the numbers with 1 attack, 2 attacks, etc

Another useful index is the ratio of the number of sufferers, during a given period, to the population A proportion of these may be suffering from illness of several years' duration as distinct from new cases starting in the period, but such still represent sufferers from the disease at a definite point of time

The difference between these two indices may be illustrated by reference to the cancer incidence in Pittsburg and Alleghany County, Pennsylvania (*Public Health Reports of U S. Public Health Service*, 1940) The number of cases first seen in 1937 is recorded as 2,507 and these, related to an estimated population (for 1930), give an *attack rate* of 1 8 per 1,000 But the doctors reported 4,622 persons attended for cancer (alive and dead), which gives a *prevalence rate* of 3 4 per 1,000

Failure to discriminate between these two indices—number of attacks and number of persons attacked—has led to many false deductions, and it is encouraging to note that in the United States statisticians now tend to adopt the distinguishing terms morbidity incidence and morbidity prevalence

Mortality Statistics

Statistics of mortality are of but little assistance in measuring the incidence or prevalence of a disease, the fatality of which is small Only where the disease has a fatality rate of 100 per cent, *and* death occurs within a very short time of onset, will the number of deaths equal the number of new, or total, cases in any year.

Rabies is the only instance which comes to mind in which every recognised human case dies and within a relatively short period after onset. In other diseases which are eventually nearly always fatal,

e g. cancer, the duration may be a matter of years, and many sufferers die from intercurrent diseases to which the death is credited in the vital statistics, so that the total deaths recorded are less than the number of sufferers.

Statistics of Notifiable Diseases

Within the United Kingdom, medical practitioners are by law required to notify all cases coming to their notice of certain diseases, and within this field one might suppose the incidence to be easily measurable from the aggregate of notifications Yet it is notorious that only in regard to a few diseases is notification even approximately complete, and this in spite of the legal penalties, whilst the degree of completeness varies in different areas, and is affected by various factors, a common one being stimulation due to topical interest.

Non-notifiable Diseases

Since estimates of the incidence of notifiable diseases are so imperfect, how much more difficult is the subject in relation to those diseases where notification is only voluntary or non-existent In this ured, generally of the sample inqu procedures of fairly recent deve *ght of such modern methods* of statistical analysis, a survey of the literature shows how inadequate have been the various indices and methods used on which past estimates of the incidence and prevalence of rheumatism have been based Hospital statistics in particular provide excellent hunting ground for the destructive statistical critic I have, in fact, been able to find only three reliable sources of information in this country as to the incidence of rheumatism First, the report generally known as the "Practitioner's Enquiry" (*Ministry of Health Reports on Public Health and Medical Subjects*, 1924) Although it has its limitations and relates to a quarter of a century ago, all later estimates up to 1944 are based on it Next we have a series of annual reports by the Department of Health for Scotland (1939) Of these the seventh is by far the most enlightening Lastly during the war morbidity surveys made on representative samples of the population have been published from time to time (*Monthly Bulletin of the Ministry of Health and the Emergency Public Health Laboratory Service*) I shall examine each of these three sources of information in some detail

1. Ministry of Health's 1924 Report on the Incidence of Rheumatic Disease

This was concerned only with insured workers as defined by the then existing provisions of the National Insurance Acts, viz. manual workers and all other persons remunerated at less than £250 per annum Thus it covered 13½ million persons out of an adult population of about 27 million, or 50 per cent Most regrettably, the exclusion of housewives was inevitable.

The procedure was to invite practitioners to act as "observers"

and record during 1922 all *patients consulting them for rheumatism.* In the aggregate, the number of insured persons on the panels of the practitioners who took part in the investigation numbered 90,891 and were believed to be representative of the insured population over the country generally, of which they formed a one-hundred-and-forty-ninth part But rural areas were poorly represented, as were also the north-western districts of England, and also Wales, whilst the basing of the material on insured workers meant in those days that, in this, as in most types of social investigation, it was limited to the less well-to-do That the sample was not completely representative of the general population is a fact which has always to be borne in mind in interpreting the results, the chief of which will now be stated.

(1) Of the 90,891 persons observed, 42,288 (46·5 per cent.) consulted their doctors during the year 1922. This is not the number of consultations but the number of patients seen, a patient seen twice for different complaints counting as one.

(2) 2,510 (1,771 male and 739 female) patients were diagnosed as suffering from rheumatic disease, i e 2·76 per cent. of the total observed (3·05 per cent of the males and 2 25 per cent of the females). This low rate for females is no doubt due to the fact that a very large proportion (46 per cent) of insured females were in 1922 within the age group 16 to 24, where, as will appear later, rheumatism prevalence is relatively low

(3) Of the 42,288 patients who sought medical advice 5 9 per cent did so for rheumatic disease

In the sense of the distinction made at the beginning of this chapter between "incidence" and "prevalence," it is clear that what we get from the "Practitioner's Enquiry" is *not* an attack rate in the true sense of the term—because no person *could* be credited with more than one attack of any disease—but the rate of prevalence of rheumatism—2·76 per cent of the population observed were sufferers. It is very necessary to bear this in mind since Table V of the report is misleadingly headed "Attack Rates" It is the number of persons *attacked—not the number of attacks*

Geographical divisions —The incidence was found to be excessive in the north-western division of England and below the average in Wales, but it must be remembered that these are precisely the two areas which were inadequately represented.

Age distribution.—By making the assumption that the population at risk (90,891) were distributed by age in the same proportions as members of Approved Societies generally, the following figures (taken from the report) show the prevalence of rheumatism per 1,000 of the insured population in each age-group (Table I).

Three points are noteworthy (1) That the prevalence increases with age in both sexes (2) That except in the age group 35–44 the rate for females is always the higher The crude rate at all ages masks this excess amongst females. (3) The crude prevalence rate for rheumatism in England and Wales from these data is 27·6 sufferers per 1,000 persons.

TABLE I

ALL RHEUMATIC DISEASES, ENGLAND AND WALES, 1922

	Rate per 1,000	
	M	F.
15 –	8 95	12 27
25 –	15 09	15 37
35 –	30 99	24 53
45 –	50 40	54 73
55 –	72 34	82 07
65 +	132 18	182 51
Ages 15 +	30 5	22 5
	27 62	

2. Scotland. The Department of Health's Seventh Report on Incapacitating Sickness in the Insured Population of Scotland

This report covers the period July 1, 1936, to June 30, 1937 A brief summary of comparable data for the following year, 1937–38 has been included in a report of the Department of Health for Scotland (1945) This deals mainly with the incidence of new cases arising during each year and specifically mentions the committee's inability "to assess with any precision the *prevalence* of rheumatism" For the year 1937–38 there were 45,000 fresh incapacities over and above those continued from the previous year. Altogether 3,000,000 working days were lost due to certified illnesses from rheumatism, of which just under one-half were due to incapacities existing throughout the whole year

But it will prove more valuable here to discuss the more detailed report of the year 1936–37 It is not a sample investigation, but is based on the whole of the insured population of Scotland, estimated to number 1 787,700, or 48 per cent of the total adult population The amount of illness experienced by these insured persons is tabulated under four headings

(a) Cases commencing in previous years
  (1) Terminating during the year.
  (2) Current over the whole year

(b) Cases commencing during the year
  (1) Terminating during the year.
  (2) Current at the end of the year

From the material provided I attempted to estimate the number of rheumatic sufferers in the insured population as follows

From Appendix II of the report I aggregated the number of recorded illnesses from rheumatism which commenced during the year (groups b_1 and b_2 above). They form the first item of Table II.

TABLE II

ESTIMATED NUMBER OF RHEUMATIC SUFFERERS IN SCOTLAND (INSURED POPULATION) 1 VII 36–30 VI 37

	Men	*Women*
$b_1 b_2$ Number of illnesses commencing in current year	35,148	13,167
Divide by 1·5 to give number of sufferers	23,432	8,778
a_2 Add number of illnesses current over whole year (=persons)	2,208	1,765
a_1 Add 24 per cent a_2 = number of illnesses commencing in previous years terminating in current year	530	424
Total rheumatic insured persons	26,170	10,967
	37,137	

These are attacks, and no indication is given as to the frequency distribution of the number of attacks per person (see paragraph 2 of this chapter) I was therefore at a loss to deduce the number of sufferers to whom these illnesses occurred Obviously there was more than one attack per person, i e among the 35,148 rheumatic illnesses recorded for males some must have been recurrences within the year to the same man But again, to assume that they represent only half that number of men would be rating the average number of attacks (2 per person) too high Somewhere between 1 and 2, say 1·5, attacks per person would seem a likely figure, and dividing the totals by this factor gives as good a guess as any at the number of sufferers who had at least one attack of rheumatism commencing during the year 1936–37 (Table II)

In addition to these, we have the number of chronic cases current over the whole year (group a_2 above), and such account for one case per person They are given in Table XVII of the report

Finally there is the group (a_1 above) of illnesses which commenced in previous years but terminated during the current year. No figure is given as to the number of these We do know that for all causes of illness they accounted for 2,729,550 days of sickness as compared with 11,225,210 credited to group a_2 (24 per cent.), a ratio approximately constant for men, single and married women, and it was considered justifiable to assume that the number of persons to be credited to group a_1 is also 24 per cent of the number in group a_2.

On the basis of the assumptions made above I arrived at an estimated figure of 37,137 insured persons (at ages 15–65) (26,170 males and 10,967 females) who experienced at least one certificated illness in Scotland from rheumatic diseases during the year July 1,

1936–June 30, 1937, out of a total insured population of 1,787,700. This gives a crude prevalence rate of 20 8 sufferers amongst every 1,000 persons

3. Health Surveys made by the Wartime Social Survey

Commencing in January 1944, field workers of the Wartime Social Survey interviewed each month a sample of the population, throughout the country The method of sampling was to choose the localities to be visited, distributed in proper proportions as to region (rural and urban) and size of town, assign to each the required quota according to the estimated population and select that number of persons, aged 16–64, at random from the local food register The persons selected were questioned as to their health during the preceding three months, thus providing records of all illnesses, distinguishing causes and degree of severity Different areas were [illegible] month were 1 in 1,000,

From the statistical analyses of these records published by Dr P Stocks (*Monthly Bulletin of the Ministry of Health and the Emergency Public Health Laboratory Service*), I have collated the following incidence figures for rheumatism—arthritic, muscular or unspecified types (M R C codes 10, 700–706) Unfortunately for comparative purposes interstitial neuritis and sciatica are thus excluded from this survey whereas in the "Practitioner's Enquiry" and in the Scottish reports (vide supra) they were included

MONTHLY FREQUENCY OF RHEUMATISM IN 100 PERSONS AGED 16–64 DISTINGUISHING INCAPACITIES FOR ONE DAY OR MORE

Month	*Recorded Illnesses per 100 persons*	*Incapacities of one day or more per 100 persons*
Oct 1943	2 7	0 5
Nov ,,	2 6	0 5
Dec ,,	3 2	0 6
Jan 1944	3 9	0 7
Feb	5 0	1 3
Mar	*	*
Apr	3 7	0 4
May ,,	3 8	0 5
June ,,	4 9	0 4
July	5 4	0 5
Aug	5 8	0 3
Sept ,,	7 6	0 7
Average of 11 months	4 2	0 57

The frequencies on which these monthly figures are based are regardless of other illnesses experienced by the same person They are the average numbers affected by rheumatism per month

Nevertheless, they are not entirely free from ambiguity, the deductions *to be made depending on the meaning ascribed to the statement that* "different areas were selected (for survey) each month." If no area *could* be surveyed twice in the same year then the result can be interpreted in terms of prevalence—number of persons attacked. But if any portion of the country was included more than once, then since theoretically every person has an equal chance of inclusion in each sample, more than one attack could have been recorded for the same person

On the first interpretation the average monthly prevalence rate of rheumatism, incapacitating for at least one day, is 0 57 per cent., which is equivalent to 72 persons out of every 1,000 during the year. When *illness of a non-incapacitating degree is included the annual* figure is as high as 504 persons per 1,000, which suggests that, in some cases at least, attacks to the same person were ascribed to different persons

Discussion of the Foregoing Estimates of Rheumatism Prevalence Rates

Three divergent figures have been reached: 27 6 per 1,000 for England and Wales in 1922, 72 per 1,000 in 1943; 20 8 per 1,000 for Scotland in 1936–37 Before accepting these at their face value with their obvious implications, one needs first to be certain that they are measures of the same thing and also that the differences are not artificial—due to extraneous factors

The England and Wales rate for 1922 referred to sufferers amongst the insured population at all ages above 15, and included a proportion of persons at ages above 65—where rates are very high The Scottish figures refer only to insured persons between ages 15 and 65 When *the England and Wales series is also restricted to this range the crude* rate is reduced to 25 5 per 1,000

It has been noted (Table I) that prevalence increased with age, whence it follows that populations with a high proportion of old people will show an artificially high rate Clearly, therefore, a study of the populations from which the rates are derived is essential to see whether in both countries the proportions exposed to risk at different ages are much different It is found, however, that the sex and age distribution of the insured population of Scotland in 1936–37 was not sufficiently dissimilar from that of the insured population of England and Wales in 1922 to materially affect the difference between the crude rates of the two countries Hence, as regards the prevalence of rheumatism amongst the *insured* population of England and Wales in 1922 and Scotland in 1936–37, I conclude that the relative position is truly given by the respective rates of 25 5 and 20·8 per 1,000.

But attempts are frequently made to extend the scope of the comparison and assume that what is true of the insured is also true of the general population This is erroneous, because the age distributions of the insured and general populations are very different. For one thing, as already pointed out, the former excludes house-

wives. In f
at ages 15–6
23 per cent
tion, whilst females between ages 55 and 64 comprised 8 per cent. as compared with only 1·5 per cent. in the insured group, so that in passing from the insured population in 1922 to the general population in 1938 additional weight is given to just those sections in which the incidence of rheumatism is highest.

I have calculated the expected number of sufferers who would have consulted doctors for rheumatism in 1938 in England and Wales on the assumptions that the specific age-group rates of the insured population not only remained constant from 1922 to 1938 but were also applicable, age group by age group, to the general population (both very questionable assumptions). In the aggregate the expected number would have been 913,617 (424,300 males and 489,277 females) between ages 15 and 64. Relating this number to the total population within the same range gives a prevalence rate of 31·7 per 1,000.

Simil
populatic
in 1938,
would have consulted for rheumatism, or an expected rate of 23·1 per 1,000.

No striking differences exist between the percentage age and sex distributions of the general populations of the two countries and it may therefore be concluded that by this method of comparison the relative positions of England and Wales and Scotland in 1938 can be expressed as 31·7 to 23·1.

It may well be questioned whether a comparison between two countries *based* on rates referring to such widely separated points of time, and involving such empirical assumptions, has any practical use. Yet these estimates and comparisons *are* constantly being made and receive too ready acceptance by the medical profession. The writer's object has been to demonstrate how involved and untrustworthy all such estimates are, and to show that in England and Wales at least they all rely for their basis on an investigation now nearly a quarter of a century old.

No doubt, improved conditions resulting from the end of the war will soon enable the organisation which produced the Scottish figures for the insured population to function again. It is hoped that in future those reports will present the number of sufferers as distinct from the number of attacks. But in England and Wales there *appears little hope that insurance data will be statistically analysed* in the same manner. It is obvious, however, that one cannot continue indefinitely to estimate the rheumatism prevalence of this country from data collected in 1922 and the information provided by the Health Surveys is a welcome addition to modern knowledge. But it must be remembered that these latter measure an entirely different if in many ways a preferable aspect.

The prevalence rate of 72 per 1,000 given by these surveys for

1943 to 1944 is not on all-fours with those so far discussed for England and Wales and Scotland. *Those* referred only to certified illness generally of an incapacitating nature of more than three days' duration The new material relates to all persons suffering from rheumatism incapacitating for one day or more, and is derived directly from samples of the *general* population between ages 15 and 64.

Occupational Prevalence of Rheumatism

I have no hesitation in stating that for this country, with the official data existing at the present time, the arranging of occupations (or industries) in order of preference according to the degree of rheumatism prevalent amongst the workers is an impossible task.

Assume that we have had a very large number of persons of all occupations under observation for a suitable period and have recorded the number who have during that time suffered from rheumatism Then the prevalence rate we should obtain for any specific occupation would be the number attacked at least once out of those classified as belonging to the specified occupation group

Clearly then it is essential that we know the number in each occupation amongst the total under survey, and it is precisely in this respect that most investigations of the question before 1940 fall short In the "Practitioner's Enquiry" the total persons under survey were the panel patients of 49 practitioners in various parts of the country The only information available as to their occupations was first, the general make-up of the practitioner's panel—one, *for example consisted very largely of dock-hands—and next the* chief occupations of the districts in which the practices were situated. This information was totally inadequate for even an approximate classification of the occupational distribution. All that could be done therefore was to classify the actual rheumatic sufferers by occupation, with the following result (Table III).

The objection to this method is that unless the population amongst *which these sufferers are observed represents the occupations in the* correct proportions—i e the same proportions in which they appear amongst the total population of the country—then it is purely coincidence if the percentage found for any occupation is correct

To illustrate 13 per cent of the male population of England and Wales were (at the 1921 Census) normally engaged in the group of occupations classified as "metals, machines and implements" But if the sample of the population under survey were so imperfectly representative that as high a proportion as 20 per cent. of the males were engaged in that occupation, then perforce an artificially high percentage of the total patients occurring in the sample will be found to belong to that occupation Furthermore, since the percentages for the various classes must add up to 100, the percentage for all other occupations would be automatically reduced Thus the over-representation of one occupation falsifies the results of all other occupations

TABLE III

OCCUPATIONAL DISTRIBUTION OF RHEUMATIC PATIENTS, ENGLAND AND WALES, 1922

Males	*Number*	*Per cent of Total*
Clerks and commercials	79	4.5
	189	10.7
	64	3.6
	128	7.2
	396	22.4
	120	6.8
	82	4.6
	26	1.5
	15	0.8
	26	1.5
Paper, printing, etc	22	1.2
Textile fabrics	77	0.4
Dress, including boots	47	2.7
Food, tobacco, drink and lodging	37	2.1
Gas, water, electricity, sanitary	43	2.4
General labourers	242	13.7
Miscellaneous and not stated	248	14.0
Total	1771	100.0

Females	*Number*	*Per cent of Total*
Shop assistants (excluding food)	44	6.0
Domestic service (indoor)	156	21.1
Outdoor charwomen etc	133	18.0
Laundresses	25	3.4
Metals	24	3.2
Clerical	43	5.8
Chemical	8	1.1
Leather, skins, etc	11	1.5
Paper printing, etc	15	2.0
Textiles	48	6.5
Dress machinists (including boots)	127	17.2
Food (including dealers) / Board, lodging / Drink	69	9.3
Miscellaneous	36	4.9
Total	739	100.0

Those responsible for the Ministry of Health's report were fully aware of this fallacy and have carefully qualified their findings. Unfortunately, [illegible] those who quote the r[illegible] serve

Precisely th[illegible] lyses of 1,000 cases (Fletcher and Lewis-Faning, 1945) which after primary

classification by occupation were combined to show the proportion falling into the following groups:

TABLE IV

TYPE OF OCCUPATION IN 1,000 RHEUMATIC PATIENTS

Males	*Number*	*Per cent of Total*
Heavy outdoor workers	89	28
Other outdoor workers	62	19
Indoor workers on materials	62	19
Other indoor workers and those not gainfully occupied	111	34
Total	324	100

Females	*Number*	*Per cent of Total*
House duties and not gainfully occupied	553	81
Office workers, shopkeepers, shop assistants	65	10
Factory workers and cleaners	58	9
Total	676	100

These patients were all attending rheumatism clinics in the London area and here again the population from which the 1,000 cases were drawn was unknown, and it is therefore impossible to say to what extent the groups correctly represent a similar classification of the whole population. The percentages must be accepted as applicable to these 1,000 cases only, and no generalisation attempted.

It may be thought that since the Scottish reports covered the whole insured population of Scotland, and not a sample of it, a satisfactory occupational analysis of the data could have been made. Special reports on particular industries have been issued from time to time on that material, but the great drawback to using National Health Insurance data for analyses of occupational morbidity is that the only occupation recorded is that which obtained when the member joined his approved society Hence "apprentice" and other junior groups falsely appear in the records to an enormous extent. Change of occupation is notified relatively seldom This may not be of material consequence where one requires the incidence or prevalence rate for an entire industry and where—as for example in the case of iron and steel workers—the sickness insurance of practically the whole industry is carried out by one or two approved societies But it is of immense importance in the large societies, whose membership embraces *all* trades and types, and where records

of occupations are seldom up to date This fact alone precludes satisfactory analyses of national sickness insurance records

Also it has long been my view (and not only as regards rheumatism) that the occupation of the patient at the time he consults a doctor may be entirely unrelated to the complaint. Rather is it true that some occupation followed during an earlier period of life may have been the predisposing factor I would therefore suggest to those who incline to record-keeping that the main occupation during the ages 15–35, 35–55 and 55 and over, should always be recorded, together with the patient's opinion as to whether each was light or heavy work, indoor or outdoor

In a few specific industries the rheumatism incidence *has* been statistically estimated Vernon (1921) found that attack rates amongst steel workers increased from 17 6 per 1,000 at ages 16–29 to 78 5 per 1,000 at ages 55–69 Comparable rates for printers were found by Hill (1929) to be 9 and 50 3 per 1,000

Whether in the future, the material collected by the Wartime Social Survey will attain to such proportions as will warrant occupational subdivisions and analyses is conjectural Provided the samples of the population interviewed are really random, and thus correctly represent all occupations in *all* areas, there is no theoretical reason, once sufficient records have accumulated, that such analyses should not provide valid data which would enable occupations to be ranked according to the amount of rheumatism which occurs in them

Occupation and Type of Rheumatism

Objections to dividing the total rheumatic prevalence in any sample of rheumatic patients by occupation and type of rheumatism in order to see whether the two factors are correlated, are less serious As an example of what may be done, I have calculated from the Ministry of Health's 1924 report the percentage frequency distributions by type of rheumatism in certain specified occupations

For males the salient features are (Table V)

(*a*) That of 64 persons classified as *agricultural workers*, and who consulted *for rheumatism*, 10 (*or* 15 6 *per cent*) were recorded as suffering from rheumatoid arthritis

(*b*) 20 per cent of the rheumatic consultees who worked in *mines and quarries* suffered from sub-acute rheumatism

(*c*) 16 7 per cent of those patients who were occupied in *building* and *works of construction* consulted for gout

(*d*) Muscular rheumatism and lumbago, which together may be classed as fibrositis, comprised at least 50 per cent of all rheumatic patients in each specified occupation except building (49 1 per cent) and agriculture (45 3 per cent)

All these features are significantly (statistically) in excess of the average for other specified occupations It should be noted that I have confined my deductions to specific occupations. No valid deductions can be made from the percentage figures where several occupations are combined, as in those columns of the table headed

TABLE V

PRACTITIONER'S ENQUIRY

Male Rheumatic Patients

	Clerks and Commercial	*Conveyance of Men, Goods and Messages*	*Agriculture (on Farms, Woods and gardens)*	*Mines and Quarries*	*Metals, Machines, Implements*	*Building, Works of Construction*	*Wood, Furniture and Fittings*	*General Labourers*	*Others*	*Total Sample*
Acute rheumatism	3.8 (3)	5.3 (10)		3.9 (5)	2.8 (11)	4.2 (5)	2.4 (2)	1.7 (4)	2.3 (11)	2.9 (51)
Sub acute rheumatism	13.9 (11)	9.0 (17)	7.8 (5)	20.3 (26)	11.6 (46)	7.5 (9)	4.9 (4)	10.3 (25)	5.5 (26)	9.5 (169)
Muscular rheumatism	26.6 (21)	18.0 (34)	12.5 (8)	15.6 (20)	22.2 (88)	15.8 (19)	18.3 (15)	20.2 (49)	23.1 (109)	20.5 (363)
Lumbago	25.3 (20)	35.4 (67)	32.8 (21)	40.6 (52)	30.6 (121)	33.3 (40)	31.7 (26)	40.5 (98)	29.5 (139)	33.0 (584)
Sciatica .	12.7 (10)	6.9 (13)	9.4 (6)	5.5 (7)	10.9 (43)	5.0 (6)	12.2 (10)	7.4 (18)	12.5 (59)	9.7 (172)
Rheumatoid arthritis	7.6 (6)	3.7 (7)	15.6 (10)	2.3 (3)	2.8 (11)	7.5 (9)	3.7 (3)	5.4 (13)	4.5 (21)	4.7 (83)
Osteoarthritis	3.8 (3)	9.0 (17)	10.9 (7)	3.9 (5)	10.4 (41)	5.8 (7)	15.9 (13)	7.9 (19)	7.9 (37)	8.4 (149)
Gout	5.1 (4)	9.5 (18)	4.7 (3)	3.1 (4)	7.3 (29)	16.7 (20)	8.5 (7)	5.4 (13)	11.0 (52)	8.5 (150)
Chronic joint changes (unclassified) .	1.3 (1)	3.2 (6)	6.3 (4)	4.7 (6)	1.5 (6)	4.2 (5)	2.4 (2)	1.2 (3)	3.6 (17)	2.8 (50)
All rheumatic diseases	100.1 (79)	100.0 (189)	100.0 (64)	99.9 (128)	100.1 (396)	100.0 (120)	100.0 (82)	100.0 (242)	99.9 (471)	100.0 (1771)

TABLE VI

PRACTITIONERS' INQUIRY

Female Rheumatic Patients

	Shop Assistants (excluding food)	*Domestic Service (indoor)*	*Outdoor Char women (etc.)*	*Laundresses*	*Clerical*	*Textiles*	*Dress (including boots), Machinists*	*Food and Drink, Board and Lodging*	*Miscellaneous*	*Total*
Acute rheumatism	11·4 (5)	7·1 (11)	1·5 (2)		11·6 (5)	10·4 (5)	15·7 (20)	7·2 (5)	5·3 (5)	7·8 (58)
Sub acute rheumatism	18·2 (8)	10·9 (17)	9·8 (13)	16·0 (4)	11·6 (5)	16·7 (8)	15·0 (19)	27·5 (19)	22·3 (21)	15·4 (114)
Muscular rheumatism	36·4 (16)	28·2 (44)	30·1 (40)	36·0 (9)	32·6 (14)	22·9 (11)	34·6 (44)	37·7 (26)	33·0 (31)	31·8 (235)
Lumbago	13·6 (6)	7·7 (12)	22·6 (30)	24·0 (6)	4·7 (2)	10·4 (5)	11·0 (14)	15·9 (11)	9·6 (9)	12·9 (95)
Sciatica	4·5 (2)	5·1 (8)	9·0 (12)		16·3 (7)	8·3 (4)	3·1 (4)		9·6 (9)	6·2 (46)
Rheumatoid arthritis	9·1 (4)	20·5 (32)	10·5 (14)	16·0 (4)	16·3 (7)	14·6 (7)	12·6 (16)	7·2 (5)	8·5 (8)	13·1 (97)
Osteoarthritis	4·5 (2)	13·4 (21)	12·0 (16)	8·0 (2)	7·0 (3)	14·6 (7)	5·5 (7)	2·9 (2)	8·5 (8)	9·6 (71)
Gout		0·6 (1)					0·8 (1)	·	1·1 (1)	0·4 (3)
Chronic joint changes (unclassified)	2·3 (1)	4·5 (7)	4·5 (6)			2·1 (1)	1·6 (2)	1·4 (1)	2·1 (2)	2·7 (20)
All rheumatic diseases	100·0 (44)	100·0 (156)	100·0 (133)	100·0 (25)	100·1 (43)	100·0 (48)	99·9 (127)	99·8 (69)	100·0 (94)	99·9 (739)

"Others" and "Total Sample." An illustration will best explain why this is so Rheumatoid arthritis is shown to be excessive amongst agricultural workers Hence, in a sample of patients covering a variety of occupations, the more agricultural workers are included the higher will be the proportion of rheumatic patients with rheumatoid arthritis In the M O H 's sample 3 6 per cent. of male patients were classed as agricultural workers, whereas the 1921 Census shows that 8 per cent of the male population of England and Wales were so occupied Hence although the table indicates that of the total 1,771 male patients 4·7 per cent. were diagnosed as rheumatoid arthritis this figure is perhaps artificially low. It must be stressed therefore that, where a sample of the population is taken which is not truly representative as regards occupational distribution, each occupation must be considered separately.

For females the significant features are (Table VI):

(a) Of 156 rheumatic patients classified as *indoor domestic servants* 20 5 per cent were diagnosed as suffering from rheumatoid arthritis and 15·4 per cent. osteoarthritis, both high percentages compared with other specific female occupations listed in the table, except perhaps textiles.

(b) An unduly high proportion, 16 3 per cent, of patients on *clerical work* suffered from sciatica.

(c) Amongst patients engaged in the *dress industry*, including *boots, and machinists*, there was an excess of those suffering from acute rheumatism, 15 7 per cent were thus diagnosed.

(d) Patients classified under the heading of *food and drink* showed an excess of sub-acute rheumatism; 27·5 per cent. being of that type

In Fletcher's and Lewis-Faning's (1945) first 1,000 cases the occupational classification was made on different lines, as indicated by the following Table VII (see opposite page)

Groups of osteoarthritis

Group A. No associated clinical characteristics.
B With obesity.
C With high blood pressure
D. With obesity and high blood pressure.
E. Traumatic and occupational.

(These letters replace the old groups A, B, D, N, H, K of the Heberden Lecture of 1939 (*Brit J Rheum* (1939), **2**, 62)

Statistical tests showed that the distributions by type of rheumatism were significantly different for the occupation groups, and the coefficients of contingency (C) obtained were 0 398 for males and 0 209 for females, from which it was evident that there was some relation between occupation and type of rheumatism.

Further examination showed that males engaged on heavy outdoor work showed excess of osteoarthritis; while other outdoor workers showed a surplus proportion of interstitial neuritis Indoor

TABLE VII

PERCENTAGE DISTRIBUTION OF EACH OCCUPATION GROUP BY TYPE OF RHEUMATISM

Males

Type of Rheumatism	*Heavy Outdoor Workers*	*Other Outdoor Workers*	*Indoor Workers on Materials*	*Other Indoor Workers and those not gainfully occupied*	*All Workers*
Rheumatoid arthritis	9.0 (8)	6.5 (4)	24.2 (15)	18.9 (21)	14.8 (48)
Ankylosing spondylitis	4.5 (4)	3.2 (2)	3.2 (2)	12.6 (14)	6.8 (22)
OA (A and spine)	19.1 (17)	11.3 (7)	4.8 (3)	6.3 (7)	10.5 (34)
OA (B, C, D, E, groups)	12.4 (11)	4.8 (3)	19.4 (12)	5.4 (6)	9.9 (32)
Hips	13.5 (12)	11.3 (7)	1.6 (1)	8.1 (9)	9.0 (29)
Gout	4.5 (4)	8.1 (5)	1.6 (1)	8.1 (9)	5.9 (19)
Fibrositis	15.7 (14)	19.4 (12)	12.9 (8)	12.6 (14)	14.8 (48)
Interstitial neuritis	14.6 (13)	24.2 (15)	19.4 (12)	9.9 (11)	15.7 (51)
Miscellaneous Ost chron S A R Rh F Malpos spine Periarthritis shoulder Unclassified	6.7 (6)	11.3 (7)	12.9 (8)	18.0 (20)	12.7 (41)
Total	100.0 (89)	100.0 (62)	100.0 (62)	100.0 (111)	100.0 (324)

$\chi^2 = 60.88$ $n' = 25$ $P = 0.00006$ $C = 0.398$

PERCENTAGE DISTRIBUTION OF EACH OCCUPATION GROUP BY TYPE OF RHEUMATISM

Females

Type of Rheumatism	*House Duties and not gainfully occupied*	*Office Workers, Shopkeepers and Shop Assistants*	*Factory Workers and Cleaners*	*Total*
Rheumatoid arthritis	30.6 (169)	35.4 (23)	24.1 (14)	30.5 (206)
Ankylosing spondylitis	4.2 (23)	12.3 (8)	.	4.6 (31)
OA (A and spine)	14.1 (78)	7.7 (5)	10.3 (6)	13.2 (89)
OA (Hips) (B, C, D, E groups)	24.4 (135)	15.4 (10)	13.8 (8)	22.6 (153)
Fibrositis	8.5 (47)	12.3 (8)	19.0 (11)	9.8 (66)
Interstitial neuritis	6.0 (33)	3.1 (2)	10.3 (6)	6.1 (41)
Miscellaneous Gout Ost chron S A R Rh F Malpos spine Periarthritis shoulder Unclassified	12.3 (68)	13.8 (9)	22.4 (13)	13.3 (90)
Total	100.0 (553)	100.0 (65)	100.0 (58)	100.0 (676)

$\chi^2 = 30.77$ $n = 13$ $P = 0.0026$ $C = 0.209$

The figures in parentheses are the number of cases from which the percentages are derived

workers on materials suffered particularly from both infective arthritis and osteoarthritis, but other types of indoor workers were much affected by ankylosing spondylitis and miscellaneous types of rheumatism

Females working on house duties showed an excess of osteoarthritis Office and shop workers suffered particularly from ankylosing spondylitis, but factory workers and cleaners were particularly affected by fibrositis, gout and miscellaneous types

It was realised that if age and type were related, then the differences recorded above might be due to an excess of younger workers in the heavier occupations, but for males no real differences *between the age distributions of the occupation groups could* be demonstrated Females engaged in house duties were on the average eleven years older than those working in offices, shops and factories Hence it is not entirely certain whether age or occupation is the more important differential factor in females Since patients with ankylosing spondylitis are on the average a younger group than patients with other types of rheumatism it may be that the excess of that type found in shop workers is due to the younger ages of those workers and not to the occupation. But since the occupational factor is clearly the more important amongst males, one is inclined to accept it for females also

Presented with the results of two investigations in the same field *of research, the temptation to abandon discretion and attempt* a comparison is usually irresistible to the statistically uninstructed investigator For the purpose of illustrating how fallacious such comparisons can be, I shall now try to compare the results of the Ministry of Health investigation with those from Fletcher's first 1,000 cases

At the outset one is faced with the difficulty that the basis of the Ministry's occupational classification was industrial, and since every industry has its own outdoor workers and indoor workers, almost every specified occupation in the Ministry's report is represented in each of Fletcher's occupational groups * The intrepid researcher might hope to circumvent this difficulty by assuming that for a first approximation the following scheme is justifiable.

MALES

Fletcher	*Ministry of Health*
Heavy outdoor workers	Agriculture, mines and quarries, building and works of construction, general labourers
Other outdoor workers	Conveyance of men, goods and messages
Indoor workers on materials	Metals, machines, implements, wood, furniture and fittings, other non specified occupations
Other indoor workers	Clerks and commercials

* *Thus within the second group—conveyance of men, goods and messages—the* work of a telegraph operator would be indoor, whilst that of shunters, lorry-drivers and vanboys would be outdoor

FEMALES

Fletcher	*Ministry of Health*
House duties	Domestic service (indoor)
Office workers, shopkeepers and assistants	Shop assistants (excluding food), clerical, food and drink, board and lodging
Factory workers and cleaners	Outdoor, charwomen, etc , laundresses, textiles, dress, including boots and machinists, all others

The next difficulty would be to obtain agreement between the diagnostic types in the two investigations, a difficulty particularly pronounced in the case of rheumatism where nomenclature has always been a matter of great controversy. Ankylosing spondylitis, osteochondritis, malposition of the spine and periarthritis of the shoulder, entities which together comprised 53 males and 82 females diagnoses out of Fletcher's first 1,000 cases, are not referred to in the tabular matter of the Ministry's report Probably it would be thought best to omit these entirely and also those classed as "chronic *joint changes (unclassifiable)" in the Ministry's report*

On the basis of these assumptions the following tabulation would result (see Table VIII overleaf)

It is difficult to imagine what deductions our investigator, faced with the obvious differences between the two series, would make from these tables In every group, the proportion of cases arising from acute and sub-acute rheumatism is at least three times as great in the Ministry's series Osteoarthritis which forms between 30 and 50 per cent in each group in Fletcher's series, only accounts for from 4 to 16 per cent of the Ministry's Fibrositis, on the contrary which covers only 10 to 22 per cent of Fletcher, never forms less than 53 per cent of the males and from 38 to 50 of the females in the Ministry series. If the differences had been in excess for some occupation groups and in defect for others, no doubt it would have been accepted that the problem of relating the occupation groups of the two series had not been solved But since the differences are all in the same direction for each type of rheumatism, this cannot be the explanation and our investigator will then suspect that the diagnostic groups are not comparable

Some of the difference might perhaps be accounted for as follows

RHEUMATIC FEVER

1 The Ministry divides their series into two

(*a*) Acute rheumatic fever
(*b*) Sub acute rheumatism These latter might be regarded as mild rheumatic fever However the instructions given for classifying the diagnoses allow this term to embrace cases that were possibly not rheumatic fever

2 It is likely that the incidence of rheumatic fever is variable

workers on materials suffered particularly from both infective arthritis and osteoarthritis, but other types of indoor workers were much affected by ankylosing spondylitis and miscellaneous types of rheumatism

Females working on house duties showed an excess of osteoarthritis Office and shop workers suffered particularly from ankylosing spondylitis, but factory workers and cleaners were particularly affected by fibrositis, gout and miscellaneous types.

It was realised that if age and type were related, then the differences recorded above might be due to an excess of younger workers in the heavier occupations, but for males no real differences between the age distributions of the occupation groups could be demonstrated Females engaged in house duties were on the average eleven years older than those working in offices, shops and factories. Hence it is not entirely certain whether age or occupation is the more important differential factor in females Since patients with ankylosing spondylitis are on the average a younger group than patients with other types of rheumatism it may be that the excess of that type found in shop workers is due to the younger ages of those workers and not to the occupation But since the occupational factor is clearly the more important amongst males, one is inclined to accept it for females also

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* Thus within the second group—conveyance of men, goods and messages—the work of a telegraph operator would be indoor, whilst that of shunters, lorry-drivers and vanboys would be outdoor

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The next difficulty would be to obtain agreement between the diagnostic types in the two investigations, a difficulty particularly pronounced in the case of rheumatism where nomenclature has always been a matter of great controversy Ankylosing spondylitis, osteochondritis, malposition of the spine and periarthritis of the shoulder, entities which together comprised 53 males and 82 females diagnoses out of Fletcher's first 1 000 cases, are not referred to in the tabular matter of the Ministry's report Probably it would be thought best to omit these entirely and also those classed as "chronic joint changes (unclassifiable)" in the Ministry's report

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(b) Sub-acute rheumatism These latter might be regarded as mild rheumatic fever However, the instructions given for classifying the diagnoses allow this term to embrace cases that were possibly not rheumatic fever

2 It is likely that the incidence of rheumatic fever is variable

country, i e. the experience of the L C.C.

3. Certain cases of rheumatic fever escape diagnosis under present conditions, (*a*) because the patient does not call in the doctor, (*b*) because the condition does not present its classical features and

the conditions of their work, would ith rheumatic fever than would the out-patient department of a general hospital.

ANKYLOSING SPONDYLITIS

Fletcher recorded 53 cases of the condition out of the 1,000 cases. Not only was the clinical picture not well defined in 1922 but the diagnosis is often impossible without X-rays. These cases would have swollen the myalgia and lumbago numbers in the practitioners' series

LUMBAGO

This in the "Practitioner's Enquiry" was probably literally diagnosed as "pain in the back" without other finding, and would

of rheumatic patients both drawn from the general population of England and Wales, yet very different in the occupations they represent The very restricted geographical limits from which Fletcher's series are taken preclude the inclusion of patients from and quarrying, fishery, part of the Ministry's latter is also relevant.
Hence even within occupational groupings the two series are not on all-fours, and this fact makes any attempt at comparability by proportional type of rheumatism very suspect.

The foregoing explanations may be summarised in the statement that Fletcher's 1,000 cases were a very select group. Almost all of them had been passed to the rheumatism centre by general practitioners and may be justly regarded as selected cases requiring special treatment Thus the milder instances of every type were excluded from Fletcher's series although forming a majority of those covered by the 1922 inquiry.

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this can be made only with the ancillary aids not usually available in general practice.

Table VIII

The Proportional Distribution of Types of Rheumatism in Occupational Groups Fletcher's first 1,000 cases compared with the M O H 1922 Inquiry

Male Patients

Type of Rheumatism	Heavy Outdoor Workers		Other Outdoor Workers		Indoor Work on Materials		Other Indoor Work	
	F % No	M O H % No	F % No	M O H % No	F % No	M O H % No	F % No	M O H % No.
Acute and sub-acute rheumatism	1 (1)	15 (79)	4 (2)	15 (27)	2 (1)	11 (100)	7 (6)	18 (14)
Infective arthritis	10 (8)	7 (35)	7 (4)	4 (7)	28 (15)	4 (35)	25 (21)	8 (6)
Osteoarthritis	50 (40)	7 (38)	31 (17)	9 (17)	30 (16)	10 (91)	27 (22)	4 (3)
Gout	5 (4)	8 (40)	9 (5)	10 (18)	2 (1)	10 (88)	11 (9)	5 (4)
Fibrositis *	18 (14)	57 (307)	22 (12)	53 (101)	15 (8)	54 (498)	17 (14)	53 (41)
Interstitial neuritis †	16 (13)	7 (37)	27 (15)	7 (13)	23 (12)	12 (112)	13 (11)	13 (10)
Total	100 (80)	100 (536)	100 (55)	100 (183)	100 (53)	100 (924)	100 (83)	100 (78)

* Muscular Rheumatism + Lumbago in M O H. classification. † Sciatica in M O H classification.

Female Patients

Type of Rheumatism	House Duties		Office Workers, Shopkeepers Assistants		Factory Workers and Cleaners	
	F. % No	M O H. % No	F. % No.	M O H. % No.	F. % No	M O H. % No.
Acute and sub acute rheumatism	3 (13)	19 (28)	4 (2)	31 (47)	6 (3)	23 (97)
Infective arthritis	34 (169)	22 (32)	46 (23)	10 (16)	29 (14)	12 (49)
Osteoarthritis	43 (213)	16 (24)	30 (15)	5 (7)	29 (14)	10 (40)
Gout	4 (20)	1 (1)			2 (1)	1 (2)
Fibrositis *	10 (47)	38 (56)	16 (8)	49 (73)	22 (11)	48 (199)
Interstitial neuritis †	7 (33)	5 (8)	4 (2)	6 (9)	12 (6)	7 (29)
Total	100 (495)	100 (149)	100 (50)	100 (154)	100 (49)	100 (416)

* Muscular Rheumatism + Lumbago in the M O H. report † Sciatica in the M O H report

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wo sets of rheumatic patients both drawn from the general population of England and Wales, yet very different in the occupations they represent. The very restricted geographical limits from which Fletcher's series are taken preclude the inclusion of patients from many important occupations, such as mining and quarrying, fishery, agriculture and others which form a large part of the Ministry's series. The omission of housewives from the latter is also relevant. Hence even within occupational groupings the two series are not on all-fours, and this fact makes any attempt at comparability by proportional type of rheumatism very suspect.

The foregoing explanations may be summarised in the statement that Fletcher's 1,000 cases were a very select group. Almost all of them had been passed to the rheumatism centre by general practitioners and may be justly regarded as selected cases requiring special treatment Thus the milder instances of every type were excluded from Fletcher's series although forming a majority of those covered by the 1922 inquiry.

The point is important, for any investigation as to the prevalence of rheumatism must include all degrees, from mild to severe. But the pr
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general practice.

Summary

1. It is shown that for the twenty years preceding 1944 all estimates of the number of rheumatic sufferers in England and Wales must perforce be based on the results of the sample investigation made by the Ministry of Health in 1922. That inquiry was not fully representative of the general population It related only to insured workers, thus excluding housewives; and certain areas, particularly rural districts, were inadequately represented. Only certificated illness was included

An estimate of the prevalence of rheumatism, say in 1938, from the 1922 inquiry involves the very questionable assumptions (a) that the specific age-group rates then found amongst the insured population remained constant from 1922 to 1938, (b) that rates derived from the insured are also applicable to the general population On this basis it can be estimated that about 914,000 persons between ages 15 and 64 would have consulted for rheumatism in 1938—a prevalence rate of 31 7 per 1,000

2 For Scotland, more recent data, collected from insurance records, provide material relating to the year 1936–37, from which, making certain empirical suppositions, and again assuming that what is true of the insured is also true of the general population, it can be estimated that in 1938, 77,300 persons in Scotland between ages 15 and 64 would have consulted for rheumatism—a prevalence rate of 23 per 1 000

3 As distinct from 1 and 2, which relate to certified illness mainly incapacitating for at least three days, figures obtained from the Wartime Social Survey Service in 1943–44 indicate that in England and Wales the prevalence rate for persons suffering from rheumatism incapacitating for one day or more was 72 per 1,000 persons between ages 16 and 64

4 It is argued that there are no data from which the relative degree of prevalence of rheumatism in different occupations can be determined.

5 There is some association between occupation and type of rheumatism Confining attention to eight selected male occupation groups—viz agriculture, mining, metals, building, furniture, general labour, clerical and transport—the 1922 report indicates that rheumatoid arthritis is more frequently met in agriculture than in the other seven occupations, sub-acute rheumatism occurs excessively in mining, and gout in building From eight female occupation groups—shop assistants, domestic service, charing, laundering, clerical, textile, dress, food and drink—it appears that rheumatoid arthritis and osteoarthritis occurred more frequently amongst domestic servants than in the other seven occupations Sciatica was relatively high amongst clerical workers, acute rheumatism amongst the dress workers, and sub-acute rheumatism amongst those engaged in supplying food and drink

6 An analysis of 1,000 cases treated at rheumatism clinics between 1933 and 1940 and classified by occupation into outdoor, indoor, heavy and light work, showed that there was an excess of osteoarthritis amongst males on heavy outdoor work, interstitial

neuritis in light outdoor work Females on house duties again showed an excess of osteoarthritis, office and shop workers were particularly affected by ankylosing spondylitis, but factory workers and cleaners by fibrositis and gout

7 Attention is drawn to the very wide divergence, even within the specified oc
distributions b
as compared
1933–40 The most reasonable explanation is that from the latter were excluded the mild type of case such as yielded to treatment by general practitioners

Conclusion

There is an urgent need for the provision of adequate data from which the prevalence of rheumatism in the country as a whole, and in different regions, and distinguishing occupation groups may be authoritatively judged There is still a wide and little explored field of study as to the relation between occupation and type of rheumatism

Two points need special consideration (1) that the *total* number of rheumatic sufferers includes those who are affected to only a minor degree, not badly enough to consult medical advice or stay away from work these can be gathered into a statistical record only by direct contact with the persons attacked, (2) that satisfactory diagnosis of the type of rheumatism cannot be made by the person attacked, and in many instances not even by the doctor in general practice, ancillary aids available only in special centres are required

There is a real problem involved in spreading a net sufficiently wide to catch all degrees of severity and subjecting them even those of mildest degree, to the most modern diagnostic procedures

E LEWIS FANING, Ph D , B Sc.(Lond)

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CHAPTER VI

PREDISPOSING CONDITIONS APPLICABLE IN MANY FORMS OF RHEUMATISM

General Considerations

ÆTIOLOGY deals with the causes of disease. The discovery of specific causes of disease by such pioneers as Pasteur and Koch has brought about a feeling amongst some medical men that such a specific causation could and should be found for all diseases. In consequence the treatment of disease would be simplified and regularised, so that we should merely be faced with the problem of early diagnosis and specific treatment. Reasoning of this type has a facile and tempting quality, but is not realistic. In regard to pulmonary tuberculosis, for example, where the prime cause has been known for fifty years, research still continues into secondary and ancillary factors The sanatorium, so far from being regarded as unnecessary, has attained more and more importance. Ryle (1942) points out that in chronic diseases like duodenal ulcer and pernicious anæmia, with no known constant causes, the concept of "multiple factors" is important He might have added chronic rheumatism *as the best example of this thesis. Just as Addisonian* Anæmia is a "pattern reaction" depending on a lack of the intrinsic gastric factor, or on a failure of intestinal absorption, so rheumatoid arthritis may be the reaction which follows a true streptococcal infection, or may be the result of an endocrine deficiency, or both. *There is no "cause" in disease but only a series of ætiological con-*siderations A study of ætiology, therefore, necessitates a consideration of all these factors, and the assessment of a particular patient, an estimate of their relative importance in the production of his morbid condition. Fortescue Fox (1938) has developed this idea, and considers the two most important external causes of rheumatism to be infection and external cold. With regard to internal factors he regards them as constituting a rheumatic "liability," and places them in three categories. *the liability to infection, the metabolic* liability, and the liability to degeneration. These three take place in youth, middle age and the senile period respectively. He correlates these features with treatment. Conceptions of this kind, although not capable of proof, are helpful

Horder in his Plea for National Action (H. K. Lewis, London, 1940) suggests also multiple ætiological factors in rheumatism and endorses the idea of a liability to rheumatism in many cases. Informed opinion as a whole supports this view and most authorities regard it as an inevitable conclusion, and the point is only argued and stressed at some length here as it has been the subject of considerable controversy in the past.

Heredity and Physical Type of Patient

In discussing the question of chronic non-specific arthritis nearly all authors mention heredity, and some postulate a type of diathesis inherited from ancestors Horder (1940) has put the matter in balanced form and argues that the change-over from the agricultural to the industrial era in Queen Victoria's reign, with its radical alteration in housing, occupation and food, may have left behind an inferiority which shows itself in rheumatic (and other) diseases

In 1,000 cases of chronic rheumatism 254 cases of infective arthritis occurred, 6·7 per cent. (15 cases) gave a family history of rheumatoid arthritis, rheumatic fever, or rheumatism Of these, 12 gave a family history of arthritis or rheumatoid (or infective) arthritis, 4 7 per cent The interrogation of patients with regard to their family history is obviously a rather delicate and a very inaccurate method of investigation, but it seems likely that the question of heredity is not an important one.

253 cases of osteoarthritis occurred in the same series, and in two cases the father had suffered from gout, and in one the mother was said to have had rheumatic fever One patient (with osteoarthritis of the knees) said her father had osteoarthritis of the hips. Again, heredity (in one generation) appeared to be a negligible factor

The case of gout is different In 40 cases of gout, 13 gave a family history of gout or rheumatism, all except one in the previous generation (32 5 per cent)

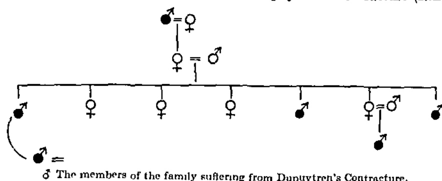
In the case of fibrositis, less than 2 per cent gave a family history of rheumatism.

The figures for rheumatic fever were too small for analysis, but Wilson and Schwertzer (1937) observed 112 families from 3-18 years and were able to predict the frequency of rheumatic fever, basing their calculation on its being transmitted as a single autosomal recessive gene
disease, they toc
with both paren
were rheumatic The penetrance is 86 per cent It seems likely, however, that the development of the disease may depend on other factors, such as environment and exposure.

A direct hereditary factor is not common either in acute or chronic rheumatism Nevertheless, there are curious and somewhat striking exceptions to this For instance, one patient suffering from Dupuytren's Contracture, a condition which shows many of the pathological features of chronic rheumatic disease, showed the following family tree (see p 122)

This family has also been affected for three generations with sporadic cases of high blood pressure and sciatica This type of family history seems to be outside the realm of chance Pemberton (1935) found hereditary influences either direct or collateral in 58 per cent. of cases studied.

Family Tree to show the incidence of Dupuytren's Contracture (R.E.)



♂ The members of the family suffering from Dupuytren's Contracture.

Family Incidence

This may be of some importance in connection with rheumatic fever St. Lawrence (1922) found that *in 50 per cent. of his cases* in children two or more members of the same family were affected, and that the incidence of heart disease was considerably raised in those people who had lived in contact with rheumatic infection.

There is little evidence of such a thing in chronic arthritis, but not infrequently more than one member of a family suffers from arthritis It is essential to exclude other common factors, such as environment and housing, before attributing this to a family cause *If these things are taken into account, it is unusual to find a convincing* familial incidence

Physical Type of Patient

It is customary in text-books to describe the type of patient who is commonly afflicted with any given syndrome These observations may be of value in diagnosis It is said that acute rheumatism attacks the fair-haired, blue-eyed child, and that "growing pains" occur in those with brown eyes and brown or black hair. Matthew Young (1933) analysed 1,000 children at Great Ormond Street and could find no type which could be recognised as "rheumatic"

So far as chronic non-specific arthritis is concerned the method has some value, for the type of patient who suffers from infective arthritis (and rheumatic fever) is as a rule quite different from the osteoarthritic In infective arthritis one finds, as a rule, an asthenic pale individual, showing symptoms of poor nutrition, and with evidence of increased vasomotor activity The pale or sweating skin, with an appreciable loss of weight, are, in advanced cases, marked features, but it must not be thought that all cases show such stigmata In mild cases, even though joint changes are very evident, the constitutional symptoms may be almost or entirely absent In osteoarthritis the stout, possibly lethargic patient is the rule. Of a robust constitution, with an active, alert mind, he is the antithesis of the rheumatoid type The gouty patient, more often than not, also belongs to this type, although in recent years so many exceptions perhaps fail to prove the rule.

Past Life and Previous Medical History

Presumably our lives and occupations to some extent condition our bodies, so that they become more or less liable to certain degenerative, infective, or neoplastic diseases Few people would deny that the Stock Exchange jobber working on a narrow margin becomes especially prone to certain disorders associated with high blood pressure and vascular sclerosis, or that the phlegmatic farm-worker with his hard manual work may develop osteoarthritis of the spine In the section on Incidence, Dr Lewis-Faning has studied the effect of occupation on rheumatism Little is known of the effect of early

Climate and race —Poynton and Schlesinger (1937) emphasise the effect of climate on rheumatic fever, but say that whereas before the war the occurrence of rheumatism amongst British troops in India was greater than among the same troops when quartered in Scotland and Ireland, the ratio in the native Indian Army was lowest of all On the other hand, rheumatic carditis is rare in Dutch children (van Breemen 1928) Various authors have shown that rheumatism has an incidence in the tropics 15–20 times less than that in Europe Bach (1930) gives a good description of the geographical distribution of acute rheumatism in his Chadwick Lecture

In the Ministry of Health report (1924) it was shown that the rheumatic incidence was 50 per cent greater in the north west of England than in the south-west, but Horder (1940) thinks that this figure may be affected by the greater number of industries in the north-west in which a special liability to rheumatism is found Other factors may also have been concerned

Meteorological observations —Coste and Forestier (1938) have studied the effects of weather and climate on rheumatism They say it is generally admitted that rheumatism occurs more frequently in the winter, but some people find that chronic arthritis is worse in spring and autumn, and others in early autumn and late winter Rheumatic fever is found more often in the north than in the warmer southern regions, both in Europe and U S A The question of weather has been more precisely studied from three points of view (1) atmospheric potential, (2) atmospheric conductability, (3) direction of atmospheric ionisation

Coste and Forestier go into these different points in detail and those interested should read the article in question On the whole the authors attribute the greatest importance to climate in cases of rheumatic fever, less importance in rheumatoid arthritis and little importance in osteoarthritis

Hench at the Mayo Clinic, thinks that arthritis patients should
cc be encouraged to disturb
tl limate This is a matter
w ations with patients, and
it om moving from place to
place in the hope of bettering their condition Psychological and

the syndrome is exposure to cold and immersion is not necessary. The degree of cold *must not be sufficient to freeze the tissues* or frostbite will follow The conclusions and deductions to be made from this syndrome cannot be usefully applied to rheumatism, but they suffice to show that low temperature above freezing-point can cause changes *in arterial coats of the nature of fibrosis, and* degeneration in muscles and nerves Some work has been carried out on refrigeration of the limbs in the course of the war and data obtained may later be useful in the study of cold. One of its effects is a lowering *of resistance to infection and this has been proved in* animals Chilling of the feet, for instance, will give rise to such conditions as respiratory catarrhs and rheumatic affections in the head and neck People with cold, damp skin seem to be most liable to *this form of attack Patients with a temperature frequently* below normal are also unable to stand degrees of cold which others can well tolerate

It seems beyond reasonable doubt that the effect of cold is greatly enhanced by *all disturbances in the circulation of the skin. Physical* therapy is largely directed to their correction. It is also true that cold has a considerable influence on respiratory infections The close connection of many of these infections with rheumatism is *worthy of emphasis, and is a clinical point which frequently arises.*

Temperature Regulation

In normal persons temperature regulation is an effective and efficient mechanism. Fox quotes the case of Shackleton and his men, who stood up to a temperature of minus 60° F. in Antarctic regions, nearly 160° F below blood heat, without great hardship Sedentary persons stand up to a temperature 50° F. below blood heat in English winters without great discomfort On the other hand a tropical temperature of 130° F. can be borne, and two investigators entered an oven at 250° F This is an outstanding human characteristic and physiological adjustment to extremes of temperature is not diminished in highly civilised races

Rheumatic patients, however, need special protection in cold climates, as temperature regulation is poor, and this is supported by the geographical distribution of these complaints. For this reason, extremes *of temperature are badly borne, and presumably* a defect in one or other of the mechanisms for combating cold may be present.

The Skin Capillaries

The skin capillaries have been studied in the nail beds by capillary microscopy Photographs are obtained and the following points are important. In *normals* the capillary loops are thick, uniform and numerous They are all curly and the ratio of the visible length of each loop to diameter across the turn of the loop is about 3 . 1.

The capillaries in various types of chronic rheumatism are said to be separate so that the number per linear unit is low In addition, the diameter of each loop is small and the ratio of visible lengths

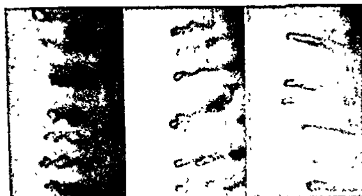


Fig 27 Fig 28 Fig 29

Fig 27 —Is a normal subject—note the loops are curly and thick The ratio of visible lengths in focus to the diameter across the turn is about 3 to 1

Fig 28 —Fibrositis loops are separated and the average diameter is 0 03 of a mm About one third are curly

Fig 29 —Rheumatoid arthritis A rather more advanced stage of Fig 28

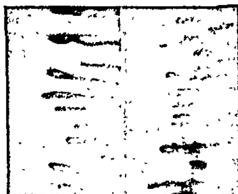


Fig 30 Fig 31

Fig 30 —Osteoarthritis The number of loops is about average, but the vessels are long and thin

Fig 31 —Roughly the same appearances as Fig 30 Some of the loops are extremely fine

Reproduced from Fox and Bremen's "Chronic Rheumatism," published by J & A Churchill, London

in focus to diameter across the loop instead of being about 3 : 1 is *more nearly 7 : 1 or 8 : 1.* The calibre is therefore fine, and curly vessels are few. Photographs are shown in Fox and van Breemen's book and seem to show the points claimed. The technique is not particularly difficult, but it seems that the appearances are unreliable If capillaries could be photographed in other parts of the body, this method might be valuable for research purposes

Diet

A distorted diet or perhaps an absolute deficiency in diet may play a part in the causation of acute rheumatism. A number of authors have written on this subject. Excess of carbohydrate is often mentioned as a predisposing cause, not only of acute rheumatism but of chronic arthritis, and some authors have quoted series of cases with apparently adequate controls where the addition of an undue proportion of carbohydrate has led to what may be termed a debilitated condition in children, with a poor appetite and hypotonic muscles These children appear to be specially liable to infection and may develop acute rheumatism. Insufficient protein and a lack of vitamin B make this more likely.

Very much the same line of thought has been followed in the case of rheumatoid arthritis (Fletcher, 1930) An unbalanced and sometimes poor diet is held to lead to stagnation in the bowel, with absorption of toxins and a lowered condition of health. A rather better case can be made out for a vitamin C deficiency in both acute and chronic rheumatism

Current opinion does not value these dietetic errors very highly, and certainly it is unusual to see any great benefit accrue from the administration of additional vitamins, although the general health may be improved in rheumatism as in any other morbid condition On the other hand, in 1933 the French journal *Nutrition* devoted a number to the consideration of digestive disturbances in chronic rheumatism and concluded that rheumatism was very difficult to treat in the presence of colonic stasis which may be due to dietetic errors Personal experience with dietetic treatment shows that *gross* dietetic errors may be important, but that minor errors seem to have little effect.

Psychological Factors

It is a matter of considerable importance to the clinician to have definite information as to the likelihood of a psychogenic basis in cases of rheumatism. This is a matter which has recently come into *prominence again, and it is widely held that family and financial* worries as well as other forms of emotional stress play a considerable rôle, especially in rheumatoid arthritis This was particularly noticeable in the London "blitz" of 1940–41, and again when the flying bombs and rockets commenced to arrive Not only were cases arising *de novo* as the result of these stresses, but old cases became reactivated

Halliday (1942) applied a psychological approach to 20 cases of rheumatoid arthritis He noted that the patients were calm and detached and called them a "quiet, decent-looking lot" He mentioned Katz's (1931) observation that the facies could be likened to the "mask-face" of Parkinsonism but could not confirm it, he noticed a poverty of facial expression but he thought it was due to habitual repression of inner emotional stresses This emotional restriction was common to all cases and was associated with obsessional trends Most of the patients were regarded as "normal" as their personality characteristics did not unfit them for life They did not belong to any psychiatric disease "type" The precipitating emotions were those which are commonly found and include shock and anxieties as a whole

In an analysis of 200 cases of rheumatoid arthritis the following precipitating emotions were found (Fletcher, unpublished)

Long-continued illness of a relative	8 cases
Air-raid incidents . .	12 ,,
Financial and business worries	14 ,,
Domestic unhappiness	12 ,,
Worry over the fate of a relative in the war	6 ,,
Fear of an expensive lawsuit and its consequences	2 ,,

In 27 per cent of cases, therefore, some emotional factor could be identified Halliday notes that these patients "bottle up" their feelings and couples this with the emotional restriction already mentioned He did not think that the disease was symbolic and did not agree with Jelliffe (1936), who said that the criminal who expresses his emotions outwardly is "locked up by others" but that the altruist who expresses his aggressions inwardly "locks himself up"

Ellman *et al* (1942) studied 50 cases labelled fibrositis from the physical and psychological sides The physical examination was negative in 23 cases, and in 27 some physical signs were found, such as tender localised muscle areas or nodules It was concluded that the physical and psychiatric findings go in inverse order, as the majority of patients with marked psychological disorder had few physical signs Of the 50 patients, however, 25 showed hysterical features or suffered from anxiety states, and 3 from depressive states This would suggest that 70 per cent of such patients suffer from definite psychiatric disorder, and this is difficult to accept as applicable generally, even taking into account the plea that they were all long-standing cases, and that the late Sir Arthur Hurst at Seale Hayne Hospital in the last war said that sciatica of more than three weeks' duration was almost always due to hysterical perpetuation Probably Ellman's cases seen at rheumatic and physical treatment centres contain an unusual proportion of difficult cases It is certain that fibrositis in soldiers does not run a comparable course with the same complaint in civilians, and of Ellman's 35 male cases 32 were soldiers

Halliday (1941) grouped a number of cases of fibrositis and interstitial neuritis under the term *psychoneurotic rheumatism* The conception that emotional stress might produce pain, stiffness and

limitation of movement, and that anxiety states were particularly liable to do so, led him to the conclusion that such a thing was fairly common. The possibility that physical therapy centres may fix such symptoms is fairly well recognised now, and it is sometimes possible to foretell such an event, so that physical treatment and its consequences may be avoided Halliday found that 39 per cent of cases of non-articular rheumatism were incapacitated by psychoneurotic symptoms

Backache without clinical or radiological signs is one of the symptoms most open to question, and Boland and Corr (1943) found 18 per cent to be due to a psychoneurosis and 34 per cent. due to what they call unstable back symptoms such as strains These cases of backache without coincident physical signs may, of course, have some lesion deep in the ligaments or aponeurosis of the back which cannot be demonstrated, but judging from their general psychological make-up it does not seem very likely At the same time, backache is one of the most trying of aches, and continual pain of this sort must lead to some psychological change. Such an explanation of the pain is more likely because prolonged rest as a rule has little effect and, if gross lesions are excluded, rest should at any rate ameliorate whatever lesion may remain Comroe (1944) quotes a case in which an advanced active case of ankylosing spondylitis was found pushing a patient with a pure psychogenic backache in a wheel-chair!

The osteoarthritic generally falls into other psychological categories The disease starts later, very often at a time when a life's work is nearing fruition and constant and steady attention to business or profession is necessary The constant pain and limitation of activity coming at such a time makes its impact in the male on an anxious, strained, forceful personality, and often produces a depressive state In the female, the same psychological result may be achieved by association with the menopause, and makes a contrast of some importance with rheumatoid arthritis.

A great deal of attention has been paid lately to the question of sciatica Hurst (1943) attributes a great deal of the successful treatment of sciatica to suggestion, and in his opinion successful treatment by injection of painful spots in muscles is due to suggestion in at least half the cases. He thinks, however, that if rest in bed for a month does not relieve the condition, physical signs of root pressure are generally found and operation relieves On the other hand, in soldiers it has become almost the rule to try rest first, and if this does not relieve, to invalid them, as operation has been found to yield unsatisfactory results If these opinions are correlated with the rather nervous depressed psychological state of these patients it will be appreciated that this aspect of their trouble ranks high as a possible ætiological factor

Perhaps the position is summed up fairly well by saying that if the psychological aspect is studied and treated in a common-sense fashion, by a physician who knows how important it may be, it can do nothing but good (Fletcher, 1941). There is no doubt that an

examination of past psychological disturbance in patients' lives may be well repaid

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CHAPTER VII

FOCAL INFECTION

HIPPOCRATES is said to have mentioned focal infection and Pemberton quotes Benjamin Rush as having cured a patient of his arthritis in 1819 by removing the teeth

In recent years there has been a varying flux of opinion as to the importance of focal infection, and on the whole the tendency has been to regard it as a factor of less importance. For instance, Cecil *et al* (1927) found focal infection to be extremely common in cases of arthritis and noted that the tonsils were the site of infection in 61 per cent of the cases, the teeth in 33 per cent, and the sinuses in 15 per cent They based their judgment as to the importance of the various foci on infection found in them and the effect of their removal In 1938, R L Cecil working with Angevine found focal sepsis to be of importance only in 20 per cent of the cases and noted that removal of these foci rarely led to improvement They expressed the opinion that foci of infection were not more common in rheumatoid arthritis than in other diseases This change of opinion goes well with current thought, but few deny that focal sepsis may be ætiological and that occasionally cases clear up well, and completely, after the removal of a focus

The usual sites of possible foci are the teeth, nasal sinuses, middle ear, tonsils and pharyngeal lymphoid tissue Occasionally the gall bladder, the prostate, the lungs, or the cervix may be concerned, and a good deal of work has been done on the bowel *B coli* infection of the genito-urinary tract is a frequent finding and may be secondary to a calculus

It seems fairly clear that the presence of a focus of infection *by itself* will not produce arthritis. Comroe quotes Brown, who found amongst 239 psychiatric patients foci in the nose and throat in 44 per cent, in the teeth in 37 per cent, and in the urinary tract in 17 per cent None of these patients suffered from arthritis

An atypical type of rheumatoid arthritis is said to occur, often of sudden onset and sometimes monarticular, which is said to be "focal" in origin When the hands are affected the swollen joints are said to be more nodular than fusiform, and various other differences are found Some people go so far as to say that these cases can be *diagnosed clinically* This is unlikely

Of the various possible foci the teeth and tonsils are by far the most common How infection occurs from a focus is uncertain, but it has been shown that a transient [illegible]
some teeth and of the tonsils, and [illegible]
sockets is said to produce the same [illegible]
doses of toxin may be intermittently exuded into the blood stream and to make this more likely "arthrotropic" toxins are suggested

Lastly, it is suggested that the protein fraction of these bacteria could produce sensitisation of the articular tissues, and some informed opinion supports this view It must be remembered that, apart from the transient bacteriæmia mentioned above, other possible explanations are without proof, apart from experimental work on rabbits Rabbits are so prone to develop arthritis experimentally that it sometimes appears doubtful whether this type of work is really helpful

Some authors say that focal infection is equally prevalent in other conditions, such as diabetes and nephritis Alport (1932) reported the presence of focal sepsis in the vast majority of cases of nephritis, and some of the original reports on focal sepsis were published in connection with such cases In certain cases there may be more than one focus, and this fact has been used to explain those cases in which removal of a focus has led to worsening of the arthritis. This has been especially applied to cases of sinus infection where removal of the tonsils has had a deleterious effect It is very difficult to assess the validity of this argument, as there are too many unknown factors.

For most people gonorrhœal and dysenteric arthritis seem to clinch the argument in favour of focal infection

The Relative Incidence of the Different Foci

Timbrell Fisher, in his book *Chronic Non tuberculous Arthritis*, quotes Willcox and Beddard who found the teeth and gums as being responsible in 90 per cent of cases Lillie and Lyons considered the tonsils to be responsible in 79 per cent of cases Pemberton (1920), in a careful analysis of 400 cases of arthritis in soldiers, found demonstrable surgical foci in 73 per cent of his cases Taking the entire series 52 per cent showed a focus in the tonsils and 33 5 per cent a dental focus 19 5 per cent showed a combination of dental and tonsillar foci Monroe (1939) found a tonsillar focus in 11 per cent of 713 cases of mixed arthritis, root abscesses in 10 per cent, sinusitis in 5 per cent, and regarded the other possible foci as relatively unimportant

In a series of 1,000 cases of chronic rheumatism 254 cases of rheumatoid arthritis occurred, 253 cases of osteoarthritis, 92 cases of interstitial neuritis and 40 cases of gout Taking as the criterion of proof those cases *only* in which removal of a focus led to an amelioration or symptomatic relief of the arthritis, the following figures emerge

Rheumatoid arthritis .	12 cases	(4 1 per cent)
Osteoarthritis	3 ,,	(1 1 per cent)
Interstitial neuritis	8 ,,	(8 6 per cent)
Gout	8 ,,	(20 per cent)

All the foci in this series were found in the teeth, tonsils, or sinuses, but in a subsequent series of 500 cases a small number of foci have been found in other sites for instance one case of rheumatoid arthritis had a focus of bronchiectasis in the lungs, and cleared

up after lobectomy, and foci have occurred in one case in the gall bladder, and in another in the kidney. These further cases are all too recent for any statement to be made about them, but the original 31 cases have been followed up for five years. Some of these fell into the war years, with their attendant difficulties, so that 8 of the 31 cases cannot be traced

EFFECT OF REMOVAL OF FOCI OF SEPSIS IN 31 CASES OF LOCOMOTOR DISORDER (AFTER FIVE YEARS)

	Cases	*Not Traced*	*Symptom free*	*Improved*	*Relapsed*
Rheumatoid arthritis	12	3	6	1	2
Osteoarthritis	3	1	1	0	1
Interstitial neuritis	8	2	5	1	
Gout	8	2	2	4	

In the cases of gout the "improved" cases all had less frequent attacks than before, but no improvement was found in the blood uric-acid readings No records have been kept with regard to fibrositis.

PERCENTAGE OF CASES RENDERED SYMPTOM-FREE AND IMPROVED AT THE END OF FIVE YEARS

	Cases	*Percentage Symptom-free*	*Percentage Symptom-free and Improved*
Rheumatoid arthritis	254	2 3	2 7
Osteoarthritis	253	0 3	0 3
Interstitial neuritis	92	5 4	6 5
Gout	40	5 0	6 0

These figures are not large enough to be of any great value, and moreover it is not possible to estimate the value of the cases which cannot be traced They give some idea of one man's experience

The assessment of focal infection in the ear, nose and throat is very evidently the province of the specialist, but the physician must have a knowledge of the type of case in which such a thing is likely. In the following section the subject is reviewed.

FOCAL SEPSIS IN EAR, NOSE AND THROAT

By W G SCOTT-BROWN

The ear, nose and throat surgeon has to guard against over-emphasising the importance of focal sepsis The tonsils, the sinuses and the ear provide a happy hunting ground for tracking down such foci and a great number of cases seen are already picked cases in which some symptoms point directly to a focus of infection as the

cause of the major illness or disease These cases further sorted and selected provide the material to be considered in giving an opinion of the type of case that benefits from eradication of such a focus There seems very little doubt that in cases so carefully selected focal sepsis plays a large part, though it has to be remembered that some clinicians believe that the so-called focus of infection plays no direct part in the general condition, i e rheumatism, arthritis, etc, and improvement is obtained only by the improvement in general health

It is, however, generally accepted, and personal experience confirms it, that foci of infection have an adverse effect on general health, and a specific effect on certain general diseases, of which rheumatism and the chronic infections of the upper respiratory tract form a large group, but other groups such as nephritis, and the anæmias, and certain gastro-intestinal conditions are also important

Chronic Rheumatic Diseases

Tonsils —The tonsils are as important a focus of infection in rheumatic conditions as the teeth, and there are certain points which suggest them as the focus There is unfortunately no sign that enables one to say with certainty they are the focus of infection, but one can classify infected tonsils into those that are a "*likely*," a "*possible*," or an "*unlikely*" focus

A history of recurrent tonsillitis associated with an exacerbation of the rheumatism give good grounds for suspecting the tonsils The case against the tonsil is much stronger if there have been associated peritonsillar infection or abscess Much less dramatic, but equally important, is the frequent sore throat, unassociated with fever or constitutional disturbance, not occurring in "attacks" but often noticed each morning

The small buried tonsil that exudes pus is a tonsil *likely* to be a focus of infection The same remark applies to a tonsil with thick, cheesy debris in the supratonsillar fossæ if this is followed, on being expressed, by a trickle of thin pus The debris has little significance by itself and can be obtained from a number of harmless tonsils

Flat, scarred tonsil remnants from which no pus can be expressed, but with injected pillars of the fauces and enlarged tonsillar glands are again likely to be the focus of infection These remains may be very small and yet be significant Probably the most dangerous remnants are those buried under the smooth innocent scar tissue following diathermy or treatment with chemical caustics The previous treatment may have improved or cured the sore throats from which the patient suffered, and a casual glance at the throat suggests tonsillectomy has been well carried out, but a faucial flush and a more careful examination reveal the buried remains

There are two points about these "likely" tonsils that should be mentioned here it is unnecessary for there to be any symptoms referable to the throat if the above signs are noted and the presence of enlarged cervical glands is not essential A preponderance of non-hæmolytic streptococci is strong confirmatory evidence It is

necessary to be dogmatic about these "likely" foci—the tonsils must be enucleated.

"*Unlikely*" foci of infection in the *tonsil cover those cases in* which there is some infection, as there is in most adult tonsils, but no definite symptom or sign indicating their removal. Such types are the innocent-looking small tonsil with no surrounding inflammation, no enlarged glands, but small "cysts" in the tonsil These often contain thickish yellow pus and might be thought to be dangerous, but the pus is often sterile and the tonsil probably harmless Again the large fleshy tonsil is unlikely to be a factor in rheumatism unless it *grows a preponderance of hæmolytic or non-*hæmolytic streptococci or is associated with the faucial flush and [illegible] the group of "possible foci" [illegible] at may provide some but not

The *nasal sinuses*, when infected, provide a less likely focus of infection than the tonsils, but they must always be excluded before enucleation is recommended, as a chronic sinusitis is a common cause of secondary tonsillitis The diagnosis of sinusitis is difficult and requires special examination, but symptoms of chronic nasal catarrh and obstruction, especially if associated with headaches, will call for *specialist examination*

It is difficult to be certain without a more extensive series of cases than are available whether the simple catarrhal infection of antrum, *frontal, or sphenoid acts as a focus of infection in rheumatism, but* undoubtedly cases with involvement of mucous membranes and submucous tissue do so, and these cases usually require radical *treatment to clear them up* This is probably a reason why an ethmoid infection is more often associated with rheumatism than any other sinus The thin body walls, the pressure of pus in a completely filled cell, and the consequent inadequate drainage probably aid the general absorption of toxins.

The case in which tonsils have been removed without benefit and a subsequent sinus drainage improves the rheumatism should not occur They do so in the group of "possible" tonsils and a "missed" sinus The large injected tonsils were really secondary to the sinusitis.

It might be thought that *chronic otorrhœa*, often representing chronic infection in the petrous bone, would be a common focus of infection, but it does not appear to be so The aural infection is *dealt with on its own account and sometimes an associated rheumatic* condition seems to benefit

The type of rheumatism associated with focal sepsis is difficult *for the nose and throat specialist to assess as a great deal of selection* by general practitioner or physician has already been done, but by far the greatest number of cases referred are of *fibrositis or rheumatoid arthritis* and in my experience it is these cases that benefit more than the others Presumably this is generally accepted and accounts for the predominance of these cases being referred for opinion and treatment.

Neuritis or neuralgia make up a number of the cases seen and cases of sciatica or brachial neuritis respond well to removal of a focus of infection.

Osteoarthritis is comparatively rarely referred for removal of a focus of infection, though a number of cases lose the acute pain and the progress of the condition is arrested after eradicating a focus. It is obvious that the damage done is permanent, but a restraining factor in sending such cases for active treatment is the undoubted aggravation of symptoms that sometimes occurs after operation on a focus of infection It might be better in these cases to deal gradually with the focus as with the teeth, employing some conservative measure as a first step Temporary improvement after conservative treatment must be followed by radical enucleation

Rheumatic fever is in my opinion often associated with infected tonsils, usually associated with the hæmolytic streptococcus, and is aggravated by each attack of tonsillitis Of all the many cases of rheumatic fever it is the type with this association that will be referred to the throat specialist, and on these cases he will base his opinion, which may be, on account of its selective basis, more *optimistic than the general opinion*

The immediate effects of eradication of a focus of infection may be an aggravation of the symptoms, and provided it is not severe this is not a bad prognostic feature The improvement usually consists of gradually longer periods of freedom from attacks, though "reminders" often occur for a long time The condition may remain unaffected at first and gives rise to doubt in the prognosis, but in these cases a late and rapid improvement may occur

Summary

Provided the clinically important criteria previously mentioned are applied, and provided the laryngologist preserves a balanced judgment on these points, the intervention of the specialist will provide little but good, but it is impossible to be certain in a number of cases whether the ear, nose or throat infection is indeed the potent focus

Dental Foci of Infection

Quite evidently this is a matter for collaboration between the physician and the dental surgeon, and it would be of advantage if this relationship could be secured more frequently It by no means follows that a mouth full of teeth which exude pus round their margins represents the *fons et origo* of the patient's malady

Physicians should be familiar with the criteria which radiologists use in their assessment of teeth This type of knowledge is difficult to acquire The following section represents modern opinion on the subject

X-RAY CRITERIA OF DENTAL INFECTION

By G. T Calthrop

The study of a dental radiograph cannot be satisfactory if the film has not been properly prepared. To produce an *undistorted* view of every tooth in every head is not easy, but unless a reasonably high standard is attained, misinterpretation is likely to occur The value of the radiograph also depends on the *photographic* quality. If the degrees of contrast are not good, values cannot be assessed.

Granted a good radiograph, one can say that there is no *evidence* of infection—if the alveolar margin is high, the periodontal membrane not thickened, the lamina dura intact, and the colour and detail of the surrounding bone good.

There are two main routes by which a tooth can become infected. (1) the root canal, (2) the periodontal membrane; that is, down the middle or down the side of the tooth

When searching for septic foci, it is commonly said that the teeth are or are not infected Radiologically this is a looseness of speech, for the evidence of infection to be seen in a radiograph of a tooth is the evidence of infection in the jaw-bone. There, it is essentially the same as in other bones, e g a whitlow affecting the terminal phalanx of a finger. The infective process results in hyperæmia, the cancellous pattern becomes indistinct, and decalcification occurs, to be followed often by hypercalcification. Thus a tooth is surrounded by bone in which the detail is more or less obscured, which looks soft, almost œdematous The infection may be active; more or less quiescent, or healed When examining a dental radiograph, it is useful first to see if a tooth shows a condition which permits infection of the supporting bone If the crown of the tooth is intact or, to put it another way, if there is not and apparently never has been an open path between the mouth and the root canal, infection is not likely to have passed down the middle of the tooth. One looks, therefore, for a fracture of the crown, for caries which extends close to the pulp chamber, or for signs that the tooth has been killed by the dentist, e g. metallic opacity in the root canal A capped tooth is not necessarily a dead or an infected tooth.

Infection of the gums, pyorrhœa alveolaris, results, after an interval, in destruction of the interdental septa and lowering of the alveolar level In addition, the periodontal membrane becomes thickened, and the supporting bone involved If the latter is normal in appearance, it is unwise to report in terms that might be construed by others to mean that infection is active. A thick periodontal membrane is often found, especially in young people. It is usually associated with bone whose cancellous pattern is made up by lines which are thicker than in other types of mouth Such patients appear to be very liable to gingival or periodontal infection; they will, however, at this stage, show a similar appearance in all teeth, and it seems a little difficult to believe that the infective process has involved all thirty-two teeth to an equal extent. This brings



Fig 32

A tooth which is dead as shown by the metallic filling of the pulp chamber and canal of the posterior root There is a fairly well defined area of rarefaction The supporting bone is hazy



Fig 33

A molar tooth in which infection as shown by the rarefaction, has travelled down the mesial aspect of the tooth



Fig 35

Two dead teeth The lateral incisor is obviously infected, because of the area of rarefaction at the apex where the lamina dura is no longer intact The central incisor is more difficult There is no real rarefaction around the apex, but the marked lowering of the alveolar level and the thickening of the periodontal membrane, renders the presence of infection almost certain



Fig 34

The alveolar margin is low, showing that infection has at some time taken place, but the periodontal membranes and the supporting bone are within normal limits This suggests that it is possible that the infection is now latent or absent rather than active



Fig 36

There is a very small rarefied area in relation to the root of the heavily filled second premolar tooth



Fig 37



Fig 38

Figs 37 and 38 These show the same teeth taken with different angles of incidence of the central ray In the one a large cystic area obviously involves three teeth, and in that its contours are not well defined, it is probably actively infected In the same film, the dead central incisor on the other side is also obviously infected In the other view, the diseased areas are much less noticeable



Fig 39

A capped and dead tooth, the apex of which has been partly absorbed as a result of infection which also has produced a rarefied area with fairly well defined walls The supporting bone is hazy Infection is probably active



Fig. 40

A molar tooth which is heavily filled, but the infection has travelled down alongside the distal aspect of the posterior root from the alveolar margin and gums



Fig 41

This part of the lower jaw shows bony detail which is not in the least hazy The patient had had an acute osteomyelitis, the result of septic teeth, whilst a prisoner of war some three years before The appearance at the present moment suggests a healthy bone which has recovered from the former severe infection, except for the scarring shown by the slight irregularities in density

forward another point in assessing the appearances—comparison with the same region of the other side If there is a difference, it must be accounted for, either by deducing the presence of infection or by radiographic technique Re-examining patients after an interval of twenty or more years, one has noted often how little change there has been The alveolar level, which was low, is no lower, the periodontal membrane no thicker, the surrounding bone is still normal in appearance It is difficult to think that an infective process can have produced changes, can have then ceased to produce more changes and be still active In such a case, surely, the infective process has been quiescent or even healed One does not isolate a person with a smallpox scar on his forehead, and equally so, if one extracts a tooth from a jaw that has apparently healed, one will not necessarily rid the owner of a septic focus When the infection travels down the root canal the periodontal membrane at the apex swells, and then the lamina dura ruptures The infection passes out into the surrounding bone This is shown by rarefaction The area involved may become localised, producing the so-called granuloma If the surrounding limits are clearly defined, and the rarefaction extreme a dental cyst has formed, and will usually increase in size and need treatment because of the local condition The removal of such a cyst, unless it has become secondarily infected, rarely has any constitutional effect. The infected area, for which search must be made, is much harder to find, and needs as perfect a radiograph as can be produced, for the rarefaction often is slight, and the outer limits ill-defined It may be that the bone in relation to this area shows a reaction similar to that produced when the infection has travelled down the side of the teeth cloudiness, blurring of cancellous pattern In both cases, instead of rarefaction, there may be an

[illegible]

area returns to a normal degree of opacity, the cancellous pattern returns, and the socket is no longer visible. If any of these changes persist, careful search should be made in the film for a retained fragment of root Sometimes the socket of the extracted tooth heals, and all looks well except a small patch of dense bone (so-called condensing osteitis This is of no serious clinical significance

In this brief review of dental radiology in relation to infection only the main points have been stressed It is a difficult subject but to those seriously interested it remains an ever-worrying and fascinating problem It is one which after a little study seems [illegible] Attempts to find slight variations from the normal and to assess their more subtle importance are beset by great difficulty.

F[illegible]

repo[illegible]

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which has been obtained, if the case is one of general or con[illegible] disturbance

Perhaps some stress should be laid on the importance of "dead" teeth There can be little doubt that vital teeth can cause clinically important focal sepsis, but there is even less doubt that dead teeth frequently do so. The dramatic recovery, for instance, in certain cases of rheumatoid arthritis and fibrositis is often associated with the extraction of dead teeth Radiological evidence is invaluable in these cases

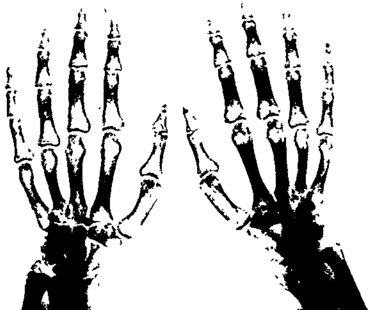


FIG 42

An example of the so called focal (asymmetrical) arthritis The left hand only is affected The focus here was an old peri appendicular abscess of many years' duration.

Other Foci of Infection: The Bowel

It is customary in most conditions in which foci of infection play an important rôle to discuss the part played by the bowel Some authors have stressed that toxins may pass from the gastro-intestinal tract to the joints Mutch (1921) believes that this is an important cause of rheumatoid arthritis, but thinks it is generally associated with intestinal stasis Constipation is a common complaint with many people, and may undoubtedly give rise to chronic ill-health if long continued, but less importance is attached to it now than used to be the case, and it does not give rise to gastro-enteritis.

The incidence of achlorhydria in arthritis seems to be no greater than in most other conditions, and far less than in some where it

may play an ætiological rôle. Pemberton, however, finds hypochlorhydria to be a frequent finding in cases of arthritis. A number of abnormalities have been demonstrated in the gastro-intestinal tract which might make it likely that abnormal amounts of toxin are absorbed. These have been mostly changes in the X-ray picture of the colon, and it is said that a balanced diet may alter these appearances.

Infection of the gastro-intestinal tract may be secondary to in-



FIG 43

To compare with Fig 42

Decalcification of one hand following a prolonged attack of herpes zoster

fection of the teeth, tonsils and sinuses. The primary sources of sepsis have been discussed under their appropriate headings.

Ulcerative colitis is sometimes complicated by arthritis, two cases have been seen in the past year and it seems possible that the colon here acts as a focus of sepsis. Apart from this condition, and perhaps occasional cases of bacillary dysentery, there is little evidence of any direct connection between the two.

The continuous use of aperients may be an unknown factor for a very liquid content
one, and we all kno
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Cruikshank says that the presence of organisms in the lower bowel may be due to abnormal conditions in the bowel contents, as the result of the arthritis He regards the bowel contents as being outside the body, and stipulates that the presence of these organisms must be accompanied by a damaged intestinal mucosa. On the whole, divided opinion is coupled with little clinical evidence Perhaps the best evidence in favour is that in selected cases reasonable colonic irrigation appears to benefit, and this could be explained as being due to an improved general health A high carbohydrate intake makes arthritic patients worse and there may be some connection between this observation and the rôle of the gastro-intestinal tract

Poynton and Schlesinger quote Arnold and Brody as saying that disturbances in the normal vasomotor reactions in dogs can be produced by making the duodenal contents alkaline. Peripheral vasodilation and leucocytosis were produced with an alteration in the intestinal flora By infusing alkalis and protein direct into the duodenum an increase in the permeability of the upper intestinal tract to bacteria was produced They consider that this makes the problem of focal infection more complex, as it introduces the possibility that it may be interwoven with considerations of atmospheric change, diet and the reaction of the upper intestinal tract

The Genito-urinary Tract

One case of arthritis has been associated with an infected hydronephrosis.

B coli pyelitis is undoubtedly a very frequent accompaniment of rheumatoid arthritis, but it has not been possible to show that its incidence is statistically significant as compared with its incidence in other conditions Treating the pyelitis has not improved the arthritis to any outstanding degree.

Chronic infection of the prostate plays some part in arthritis and presumably acts as a focus of sepsis. Some years ago a case of rheumatoid arthritis in a man of sixty-four was seen, and during the course of the examination the prostate was examined digitally. That day the blood sedimentation rate was 28 mins. at the hour (Westergren). Next day, a telephone call came to say that the patient was acutely ill and several more joints were involved. On examination t[illegible]
had risen to 40 [illegible]
explanation seems [illegible]
joints. Apart from this, it is a fairly common opinion that, excluding gonococcal arthritis, the prostate has some relationship to chronic arthritis It is doubtful whether one can subscribe to the opinion that the majority of cases of chronic prostatitis are due to non-specific infection and not to gonorrhœa. Recently [illegible] er, cases of arthritis and ankylosing spondylitis have been s[illegible] sociation with a non-specific urethral [illegible] harge and the s[illegible] of this is not yet understood.

The Gall Bladder

In 1,500 cases of rheumatism, including 377 cases of infective arthritis, the gall bladder has been suspected 10 times Cholecystograms have been taken in all cases, and gall-bladder drainage instituted with culture and chemical examination The results have never been sufficiently definite to warrant the removal of the gall bladder. Other physicians, however, appear to be occasionally successful with this procedure One case only has been rendered symptom-free by bile drainage

Pelvic sepsis is said by Robinson (1938) to be the cause of infective arthritis in women in the great majority of cases They are treated with intra-pelvic diathermy Cases of arthritis are occasionally complicated by a non specific salpingitis, it is unusual to see a case of arthritis benefited by the removal of the focus This remark would apply with even greater force to such conditions as an erosion of the cervix, and as a whole current opinion does not accept the idea The case may be a little different in cases of fibrositis

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CHAPTER VIII

LABORATORY FINDINGS IN RHEUMATISM

THE usual laboratory investigations in rheumatism may be regarded as falling into two categories: those for the purpose of diagnosis and th
branch of the first cate
conditions which cannot
Charcot's joint, or diabe
diagnosis of the type of rheumatism An important category of rheumatic cases is that labelled "Rheumatoid Arthritis" As yet, the evidence in favour of its infective origin in the ordinary sense of the term is of the slenderest description, as Koch's postulates can never be fulfilled Furthermore, less is known about the origin of rheumatoid arthritis, which Osler described as "one of the greatest of the human afflictions," than about the origin of almost any other disease.

Osteoarthritis seems to be a disease of a degenerative type, the affected joints are either of inferior material, or are subjected to unfair strain, as for example in the joints of the remaining leg when one has been amputated. The chemical, serological and bacterio-
of a negative nature
on the other hand,
tain the source of the
infection and the type of infecting agent One or two suggestive lines are appearing It occurs most commonly in young women, thus suggesting a hormonic factor, the glucose-tolerance test in the disease resembles that found in exophthalmic goitre; the extraordinary phases of exacerbation and remission have a certain significance As Boyd says, "when we come to the subject of chronic non-tuberculous arthritis, we have to sail an uncharted sea, through thick fogs and with very few landmarks that are of any value" It is the province of the pathologist and the radiologist to elucidate such landmarks as are available

Generally speaking, the work of the pathologist in a clinic for rheumatism comprises:

(1) Classifying the non-rheumatic conditions.
(2) Diagnostic investigations
(3) Investigations to control the effects of treatment.

It is not proposed to enter deeply into the first of these categories, it may be sufficient to indicate (as previously mentioned) that this
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Diagnostic Investigations

(a) **Sedimentation rate.**—Unquestionably the most valuable investigation in a case of rheumatism is estimation of the sedimentation rate. This test, the fundamental basis of which was discovered by Galen in the second century A.D., was largely rediscovered by Fahraeus, whose exhaustive researches, published in 1921, have left us very little further to investigate.

The original observation leading to the discovery of this test was, that when blood was collected from a patient who was gravely ill the top of the clot that formed in such blood was white. The white part of the clot was called the "phlegm" and was thought to be the substance causing the illness, further bleedings were undertaken to eliminate it. In actual point of fact, however, the white portion of the clot was merely fibrin without entangled red cells, the latter having settled down in the serum too rapidly to be caught by the top of the clot, which thus resembled a sugar cake. Fahraeus showed that the rate of fall of the red cells in the plasma of unclotted blood was due to the degree of rouleaux formation, the larger masses thus formed falling faster (in accordance with Stokes's Law) than the smaller ones composed of single cells or of small rouleaux only. In cases where the rate is very rapid, the rouleaux are of such size as to form small "cayenne pepper" granules that are visible to the naked eye above the level of the solid cell column. These granules are smaller than those seen in a true agglutination produced by mixing blood of heterologous groups, and microscopy will show that they are composed of rouleaux only. Patients with a rapid sedimentation rate may thus produce a "pseudo agglutination" due to such rouleaux formation which may provide a pitfall in blood-grouping procedures, and an associated phenomenon which causes some trouble in making a red-cell count is the tendency such bloods show to form groups of red cells in the count chamber instead of an even distribution. The actual formation of rouleaux is prevented by the position of the red cells lying flat on the slide, but they seem to edge together in groups as though mutually attracted. They do not, however, stick together in the irregular gummy fashion of true agglutination.

It may well be asked what substance is capable of producing such a remarkable phenomenon, but the fact is that it is of such a fugitive nature that it has not so far proved possible to identify it. The use of the term "sedimentin" by some observers gives rise to the unjustifiable deduction that such a substance exists, but it may equally prove to be some physico-chemical change in a substance normally present, such as a change in the colloidal dispersion of a substance in the plasma.

It has been maintained by some observers that the phenomenon depends upon the albumin-globulin ratio, or upon the relative proportions of fibrinogen, albumin and globulin. If this is the case, why does the rate gradually become normal if the blood, collected aseptically, is kept for some hours before the tubes are set up, especially if the blood is kept at a warm room-temperature and the

cells allowed to sediment in the specimen tube? It is hardly likely that anything so substantial as the amount of fibrinogen or the albumin-globulin ratio would be changed by such mild treatment, but much more that the colloidal dispersion is changed in some subtle way Day (1939) has suggested that the slowing of rate described above is due to some change in the red cells, making them less liable to form rouleaux At the same time Ralph and Davies (1930) showed that in pulmonary tuberculosis the results ran parallel with those of the Vernes' resorcin test, which presumably depends in some way upon the serum globulins. Unfortunately for the investigator, many manipulations of the blood directed towards elucidating the mystery seem to tend to make the phenomenon disa[illegible]

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was originally supposed that the test was an index of infection, and unjustifiable deductions resulted, but it is now abundantly clear that the increase in rate is caused by tissue damage of which infection may play no part. This was first made clear to the present writer by a case of acute gout in which the rate of sedimentation was very rapid in the absence of any evidence of an infective condition The fact has now been abundantly demonstrated elsewhere.

Technique

There are various techniques for this test, but the fundamental principles are the same Blood mixed with an anticoagulant is placed in a tube which is set exactly upright and left undisturbed The red cells settle down in the plasma leaving a clear layer above, the top of the cell column usually being sharp and clear unless the rate is very rapid or the tube bore is large The level to which this cell column has fallen is read off at intervals which vary according to the taste of the operator, for reasons which will be discussed presently, this is best carried out at the end of one hour and two hours

This much the various techniques have in common, but divergencies occur on the following points·

(i) *Anticoagulant.*—This may be (*a*) potassium exalate, (*b*) a mixture of sodium, potassium and ammonium oxalate (the special value of this mixture is not clear, and it ruins the specimen if it is desired to carry out a blood-urea estimation at the same time, (*c*) heparin, (*d*) hirudin, or (*e*) a solution of isotonic sodium citrate, added in a constant proportion This last is quite harmless and easily the most handy to prepare and use In the Westergren technique, usually employed by the writer, a 3 8 per cent solution of sodium citrate is used in a proportion of one part of citrate solution to four parts of blood This dilution with citrate produces slight slowing of the rate The slowing is, however, constant.

(ii) *Column length*—The standard Westergren length is 200 mm.; in the Wintrobe method the length is 100 mm., while in the Cutler method it is 50 mm. Theoretically the ideal length would be an

infinite one, as the shorter the initial column, the sooner a slowing of the fall occurs, owing to the commencement of packing of the cells at the bottom of the tube In a normal slow rate this is of little moment, and the readings obtained by all three methods are very similar, but as soo[illegible]
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200 mm -length of the [illegible] one method what a reading [illegible] n very slow rates where the [illegible]

(iii) *Tube bore* —A controversy has raged round the question of the ideal bore for this purpose, some writers considering that too small a bore would cause slowing owing to 'capillarity' Such a theory is untenable, as the test has nothing to do with free fluid surfaces or junctions of fluid surfaces, but merely with bodies falling through a fluid The writer has carried out an extensive investigation of this point, using tubes of varying bores from 0 3 mm to 5 mm At each experiment these tubes were filled to the 200-mm mark with blood collected from one particular patient, and set up simultaneously in an automatic photographic recorder In this manner cases of all types and rates were investigated and, as expected, the rates and curve shapes were found to be almost identical whatever the tube bore At first it was thought that the rate was actually very slightly *slower* in tubes of wider bore, but this proved to be due to the fact that the automatic recorder made no allowance for the fluffy top to the cell column occurring in the widest tubes The chief objection found by the writer to tubes of the smallest bore (and i[illegible]
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the smallest convenient size was found to be 1 mm This size is employed in the writer's own micro-method, used to give results comparable with those of the Westergren technique in cases where vene puncture is difficult or inconvenient In the writer's view, the tube bore is thus almost immaterial, and it can only be supposed that opinions to the contrary have been founded on faulty technique

(iv) *The question of correction for cell volume* —If some of the plasma is removed from a specimen of blood the rate of sedimentation is subsequently found to be slower than in unaltered blood It is also obvious that an anæmic blood is less viscous than a normal one It was, therefore, thought desirable to correct the cell volume in those bloods in which it was deficient owing to anæmia by (i) applying a correction to the results obtained by the standard technique, such correction being calculated from a hæmatocrit reading made after [illegible]

the "adjusted" blood in the sedimentation tube The latter method

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The test is of the greatest value in the investigation of rheumatism, as also in other conditions in which occult damage is occurring It was originally supposed that the test was an index of infection, and unjustifiable deductions resulted, but it is now abundantly clear that *the increase in rate is caused by tissue damage of which infection may play no part.* This was first made clear to the present writer by a case of acute gout in which the rate of sedimentation was very rapid in the absence of any evidence of an infective condition. The fact has now been abundantly demonstrated elsewhere.

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200 mm -length of the Westergren technique There is no simple method of calculating from a reading by one method what a reading by one of the others might be, except in very slow rates where the readings are very similar by all methods

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the test was finished (Wintrobe), or (ii) making a hæmatocrit reading first, and withdrawing sufficient plasma from the specimen to correct the cell volume to normal (Schuster and others) before setting up the "adjusted" blood in the sedimentation tube The latter method

is the less obnoxious of the two, but the present writer considers that any such correction is best avoided for the following reasons:

(*a*) Such correction takes no account of a not uncommon finding; a patient with some anæmia but a normal rate, and "correction" may make pathological cases seem normal.

(*b*) The idea of correcting in this manner is founded on a faulty conception of the mechanics of the test. While admitting that anæmic blood may be less viscous *as a whole*, we are here dealing not with objects falling through whole blood, but with corpuscles falling through plasma, which is not necessarily deficient in viscosity in anæmia. Furthermore, the variations in rate are the result of rouleaux formation of varying degree Deficiency in corpuscles and their wider separation in the plasma will hinder rather than help the formation of rouleaux.

(*c*) If the blood is diluted with isotonic citrate solution, saline, or other diluents the result is a *slowing* and not an increase of the rate (Fahraeus, 1921).

(*d*) Fahraeus showed that such a substance as gelatine, that increased the plasma viscosity, is capable of producing an increase of the rate of sedimentation (Fahraeus, *ibid.*).

(*e*) It is no argument to plead that slower rates are obtained by withdrawing plasma Such slowing might be due to the inevitable reduction in titre of the sedimentating substance (whatever it is) in the whole blood. Until we know more about what this substance is, it is surely best to avoid undue interference with the blood

(v) *Methods of expressing results*—(*a*) The simple and obvious method is the best. This mentions the technique, thus giving the column length used, and then states the distance sedimented at the end of one and two hours A lazy method is to cite the first-hour reading only If this is done, a substantial number of cases with slightly increased rates will be missed, as it is common for such cases to show normal rates in the first hour It was to detect such cases that the so-called "Sedimentin Index" was devised, but the best method is to read the rate at the end of two hours. If the first-hour reading is omitted, on the other hand, the more rapid cases may not seem as rapid as they really are owing to the onset of "packing" at the bottom of the tube *In extreme cases this may begin at the end* of the first twenty minutes

(*b*) *The Sedimentin Index* (Day, 1943) (Della Vida, 1942)—This method of expressing the results is carried out as follows. A series of readings is taken in the course of the first hour and these are plotted as a graph. The straightest portion of the curve is selected and a ruler laid along it The straight portion is then prolonged in both directions and from this the maximum constant velocity per 100 minutes is deduced, the straight portion of the curve being regarded as representing the period of "free fall" of the rouleaux. The "Sedimentin Index" is the logarithm of the maximum constant velocity per 100 minutes.

There is certainly something attractive about a method that expresses the result of a test by a single figure, and the originator of

the method claims greater accuracy as a result of its employment It should, however, be realised that the curves obtained by the automatic recorder often show the curve to be a double-flexure one, and the period of "free fall" is then by no means obvious It is unlikely that a method that begins with an approximation is accurate. In actual practice, however, the method does afford some information in those cases, already described, in which the first-hour reading is normal but the second-hour reading is raised It may well be doubted whether the method is superior to that of taking one reading at the end of the first hour and another at the end of the second

(c) Expressing the plasma cleared of cells as a percentage of the total volume of the blood. This presents no advantage and merely "darkens counsel"

Technique of the Westergren Method

This technique has always been found the most satisfactory, and, as it is the most universally adopted, it affords an easy method of comparing results with those obtained by other observers The test is a sensitive one, and a careful technique is essential

First, 0·4 cc of a 3 8 per cent solution of sodium citrate is drawn up in a 2 cc record syringe, the needle is inserted into the patient's median basilic or other convenient vein, and the plunger is drawn out to the 2 cc -mark It is essential that the plunger should be well-fitting, as air bubbles will interfere with the correctness of the dilution The blood thus obtained is ejected gently into a specimen tube As soon as reasonably possible (within two hours) the blood is drawn up into the Westergren tube. This is a tube like a 1-cc -graduated pipette, it is of about 2·5 mm in bore and carries a mark that is 200 mm. from the lower end As the lower end of the tube is not throttled like that of a pipette, it is advisable to throttle it against the bottom of the specimen tube, as otherwise the rise and fall of the blood in the tube will be too rapid for convenience, and the operator may get a mouthful of blood

The citrated blood is drawn up to the 200-mm mark, and the tube is set up vertically in a special rack made for the purpose. It is absolutely essential that the tube should be exactly vertical, as the slightest deviation from this may produce a great increase in rate Two degrees deviation has been known to double the rate [illegible]

[illegible] Unless the rate is rapid, the top of the cell column is usually sharp and clear, the distance this level has travelled is read off, either by means of graduations on the tube or by means of a separate millimetre scale, at the end of one hour and two hours

Occasionally, the absence of adequate veins in the patient, or the difficulty of obtaining sterile syringes and needles, may make the collection of an adequate specimen difficult As the writer's series

of automatic records with tubes of greatly varying bores showed no difference in curve, shape, or rate, it is clearly possible to use smaller tubes without altering the result, the readings obtained being comparable with those obtained with Westergren tubes. The writer has therefore adopted a method whereby the blood may be collected in such difficult cases by means of a finger-puncture and the blood drawn up into a tube of 1-mm bore, the column length used being 200 mm as in the standard Westergren tube. The pulp of the patient's finger is deeply punctured, and the drops are collected into a pipette that already contains citrate solution amounting to one-fifth of the final bulk of the specimen When the column in the pipette reaches the upper mark the blood is ejected into a watch-glass, gently stirred, and then sucked up into the 1-mm.-bore tube to the 200-mm mark It is then set up in the Westergren rack and read just as in the case of the standard Westergren tube Never set up any sedimentation tube by sticking it in plasticine or putting it in an improvised holder. It is always advisable to hang a plumb line on the tube rack as benches are often not level and tube racks have been known to warp

The writer (Shackle, J W, and Orme, C. L'E., 1937) has devised an automatic recording apparatus taking ten Westergren tubes whereby curves are plotted on bromide paper. These are subsequently measured by laying on them a graduated celluloid scale In [illegible] illuminated obliquely. Being [illegible] is recorded [illegible] short-focus wide-angle lens The traverse is sufficient to give satisfactory curves of all ten tubes without overlapping With this technique, a normal person will usually show values of from 3 to 8 mm at the end of the first hour and of from 8 to 16 at the end of the second Some observers take a further reading at the end of 24 hours, the tube being sloped to an angle of 45 degrees at the end of the first two hours. This greatly increases the rate, and the 24-hour reading will thus give a very rough-and-ready measure of the patient's cell volume The reading is virtually useless

In cases where tissue dama[illegible] sedimentation is increased, sometimes to a [illegible] values of 90 mm or more m[illegible] hour, and up to 130 mm. at the end of the second In these cases most of the sedimentation occurs during the first twenty minutes, and the first-hour reading is clearly the significant one, but cases showing only slight deviation from the normal may show, as already mentioned, a normal value of 5 to 8 mm at the end of the first hour but an increased rate of 30 to 40 mm. at the end of the second

So long as one can be sure that other lesions such as pulmonary or malignant disease can be eliminated, the test is of great value in rheumatic cases The muscular and aponeurotic cases, including lumbago and sciatica, do not show any increase in rate—a point in favour of the theory that tissue damage is a fundamental basis of the test—and if any such increase is observed, some other active

lesion is to be looked for Gout during the quiescent stage usually gives rise to normal rates, though these may be greatly raised during active phases, while in rheumatoid arthritis an increase in rate is the rule, values of as much as 120 mm in the first hour being not uncommon Such high values may be remarkably persistent, even when some clinical remission is apparent, and Orme (1935) has shown that rates of 50 mm at the end of the first hour and 85 at the end of the second have a relatively bad prognosis In spondylitis, rates of medium velocity only are usually obtained On the other hand, Fletcher (1944) has shown that cases of rheumatoid arthritis with a normal or slow rate are often extra sensitive to gold treatment and need special care if this is to be used

Where delay occurs in setting up the Westergren tube after collecting the blood, a progressive diminution of the rate may be observed This does not seem to be constant, and occasionally there is little diminution even after a delay of twelve hours On the other hand, the diminution may be very marked, and it is usually necessary to set up tubes within two hours of collection if satisfactory results are to be obtained The error seems to be worst if the blood is allowed to sediment in the specimen tube in a warm place The phenomenon has been investigated by Fahraeus with his usual thoroughness as also by Day (1939)

On rare occasions an unexpected normal result may be obtained in a case where the rate has been previously consistently rapid If the test is at once repeated on a fresh sample of blood the expected rapid rate is obtained The explanation of this phenomenon is not

seems to predispose to this occurrence but most commonly there is no such cause While the phenomenon is too rare to be of serious significance, it is always advisable to repeat the test where an unexpected result has been obtained, especially where the results are low An "all or nothing" law seems to apply in this case, the results are either rapid or show low normal values, there do not seem to be any cases in which intermediate figures are obtained It is sign

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tion rate is clearly of the very greatest value in assessing the effects of treatment, and it is quite the most valuable laboratory test carried out on rheumatic cases

(*b*) Cytological

A mild secondary anæmia is not uncommon in rheumatic cases, it is probably not more frequent than among people who are in some way disabled from leading a normal active life, and there is no evidence that it is in any way a causative factor

The white-cell count, too, rarely shows any substantial deviation from normal, even in cases of very active rheumatoid arthritis or of

the so-called infective arthritis. The infection in this case, if any, would seem to be of the low-grade or smouldering type

The introduction of gold treatment, however, has led to an increased importance in the blood counts of patients so treated, as it is inadvisable to institute this treatment where there is any degree of anæmia or where a leucopenia is present. While it is hard to lay down a definite rule, a hæmoglobin percentage of 80 per cent in men or 75 per cent in women would seem to be an indication for caution The treatment may cause a certain degree of anæmia of secondary type, but more important than this is the occasional appearance of leucopenia with agranulocytosis. Where the treatment is properly carried out, and a periodic check is kept on the blood count, these ill effects are rare The occurrence of punctuate basophilia following treatment with gold has been described by some writers. The present writer has never been able to verify this finding in spite of very numerous blood examinations, but its presence in cases where injudicious treatment with gold has led to a secondary anæmia is not unlikely.

(c) Chemical Investigations

Blood calcium —In spite of the extreme rarefaction found in the bones in some cases of rheumatoid arthritis, no dramatic changes are found in the serum calcium in any of the usual types of rheumatic disease seen in an ordinary clinic. The estimation is, however, occasionally called for, notably in cases treated with vitamin D

The technique of estimation that seems most satisfactory is that of Roe and Kahn (1929) This method avoids the use of permanganate titration which is the basis of the method of Kramer and Tisdall (1921), Clark Collip modification (1925). In the latter method, the calcium is precipitated as the oxalate and titrated with potassium permanganate, while in the method of Roe and Kahn it is precipitated as the phosphate, and estimated by colorimetry by the Youngburg (1930) technique (combination with molybdic acid and reduction)

The normal serum calcium may be taken as from 10 milligrams to 11·5 milligrams per 100 cc, between which values it remains remarkably constant. The estimation of the ionised calcium does not seem to have produced the interesting results that might have been expected, the estimation itself is not a convenient one to carry out in a busy routine laboratory The estimation in the cerebrospinal fluid, which might be expected to represent the ionised calcium of the body fluids, does not commend itself for use in an out-patients department. It may be noted, however, that the calcium-ion concentration is said to be the resultant of an equilibrium between the total protein and total calcium of the plasma, and McLean and Hastings (1935) have suggested that it can be calculated from these by means of a suitable nomogram This nomogram may be found in the very useful laboratory handbook of Miriam Reiner.

Serum Phosphatase

Acid phosphatase.—In rheumatic cases this test is seldom called for except where it is necessary to eliminate the possibility of bone marrow carcinomatosis secondary to carcinoma of the prostate, a value of over 4 units (Gutman) being suggestive.

Method (Gutman and Gutman, 1938).—The principle of this method is to ascertain the amount of phenol liberated from disodium monophenyl phosphate in a buffer substrate at a pH of 4.9 (1 milligram being taken as the unit) in an hour at 37° C.

Alkaline phosphatase.—The chief value of this estimation is in the diagnosis of Paget's Disease, a moderate number of cases coming to clinics for rheumatism on account of rheumatic symptoms. The unit is 1 milligram of phenol liberated from disodium monophenyl phosphate in a buffer substrate at pH 9.0 after half an hour at 37° C (King and Armstrong, 1934). Normal values in adults are from 4 to 12 units, while the equivalent values in children are from 6 to 20 units. In Paget's Disease very high values may be obtained.

As both these methods of estimating phosphatase depend upon the determination of small amounts of phenol, it is clearly of importance to be sure that the glassware used is not contaminated with this or its derivatives. As such disinfectants are commonly used for washing up in a pathological laboratory it is advisable to set aside the appropriate glassware for this test and not allow it to be used for any other purpose. The glassware used to dilute the Folin and Ciocalteu phenol reagent must similarly be scrupulously clean, and it is well to remember that some bakelite bottle-caps contain phenol derivatives and are best avoided. The mouthpieces of pipettes may also be plugged with cotton wool.

Blood Uric Acid

The estimation of uric acid was formerly often carried out on the urine, but the variation in concentration of this gave rise to such faulty results that this is now rarely carried out, except occasionally in the form of estimating daily output of uric acid in the whole twenty-four hours.

Of much greater value in the diagnosis of gout is the estimation of uric acid in the blood. It is important to realise, however, that some apparent failures of this estimation to demonstrate an expected raised value of uric acid may be attributable to errors in diagnosis from a clinical or radiological point of view. Thus gout was formerly thought to be causative of fibrositis, and few people will now venture to criticise the value of the uric-acid estimation because it fails to give raised values in this condition. Furthermore, the "punched out" areas seen radiologically in bone often give rise to a diagnosis

mistaken for tophi, though all attempts to aspirate uric-acid crystals (or indeed anything else) from them are fruitless.

Raised blood uric-acid values have been described in uræmia, but as the conditions of gout and uræmia are not very commonly associated in ordinary practice, and as there are usually other signs of the latter disease, a simple estimation of blood urea is all that is needed to clear up the doubt

With regard to the normal values of blood uric acid, there is a decided difference between those in men and those in women. Thus the normal values for men may be taken as from 3 to 3 8 milligrams per 100 c c, while those for women are from 2 to 3 2 milligrams. The upper limits of normality seem remarkably sharply defined, as gout is rarely seen in a case with a value of less than 3·8 milligrams per 100 c c but values of 4 milligrams are not uncommon in this disease

During an acute attack those values may be substantially raised The writer has had cases showing values of over 8 milligrams, while cases showing over 14 milligrams have been described (Osman, A. Personal communication) In considering such high values, however, it is important to know what technique has been employed, as interfering substances may give rise to spurious high values. With a proper method of estimation these may be eliminated, as will be described later

Between acute phases of gout, the percentage of blood uric acid may fall A case of the writer's giving values of 6 milligrams during the acute phase showed a fall to 3·5 milligrams during remission. Such a fall as this is, however, exceptional, and the fall is rarely enough to cause the diagnosis to be missed Most gout cases seem to have a raised value for life, and these values are sometimes remarkably constant

The comparative rarity of gout in women (though commoner among Jewish women) may possibly be referable to their normally low blood uric-acid values, there is further for the blood value to rise before the gout threshold is reached

Methods of Estimation of Blood Uric Acid

The best method of estimation still seems to be the original method of Folin, which depends upon the blue colour produced by the interaction of uric acid and phosphotungstic acid in the presence of alkaline cyanide This is the method, with a few minor modifications, that is used by the writer There are, however, one or two points that require to be considered when using the method The principal one is the occurrence in a few cases of certain interfering substances The identity of some of these is not clear, but the principal one seems to be thioneine To eliminate these substances various methods have been adopted (1) The estimation is carried out on the serum as commonly practised in America (Duncan, G. G, 1944), or on the plasma as in the method evolved by the present writer As the th[illegible] is practically all in the cells of the blood, this eliminates it [illegible]
is not clear, as neit[illegible]
to interfere On the other hand it is an [illegible]

centrifuge at once without having to wait for the clot to contract. As the cells contain practically the same amount of uric acid as the plasma the use of the latter for the estimation makes no appreciable difference to the result (2) By the use of Folin's Isolation Method, in which the uric acid is precipitated quantitatively as a compound with silver lactate (3) By the use of a uricase derived from beef kidney which quantitatively destroys the uric acid, an estimation of which is carried out before and after the incubation with the uricase The value after the destruction is deducted from the first value as it represents the amount of interfering substances present The technique of estimation used resembles that of Folin. The method is somewhat tedious, as it takes over five hours to carry it out

Folin's Direct Method (Modified) (Folin, 1922) (Folin and Trimble, 1924)

Reagents

(i) Sodium tungstate (molybdate-free) 10 per cent solution
(ii) 2/3N sulphuric acid
(iii) Standard uric acid (strong standard)

1 gram of uric acid is transferred quantitatively to a one-litre flask Make up a solution of lithium carbonate by adding 0 6 gram of lithium carbonate to 150 c c of water, shake to dissolve and filter [illegible]
acid
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20 c c of 40 per cent formalin and half-fill the flask with distilled water Add a drop or two of methyl orange and slowly add 25 c c of normal sulphuric acid The solution should turn pink when 2 to 3 c c of acid still remain to be added Dilute to volume and mix The solution contains 1 milligram of uric acid per c c It is best kept away from the light and is said to keep well for some years In the writer's experience it is best not to trust too much to this keeping quality From this prepare·

(iv) *The working standard*—Dilute 1 c c of the stock standard to 250 c c This is best renewed about once a fortnight

(v) *A 15 per cent solution of sodium cyanide* in N/10 sodium hydroxide solution

(vi) *Uric acid reagent*

100 grams of molybdate-free sodium tungstate are placed in a 500-c c conical flask Dilute 32 c c of 85 per cent phosphoric acid with 150 c c of water and add to the above Drop in a few beads to prevent bumping and boil gently for one hour with a funnel in the neck of the flask At the end of this time the fluid is nearly always darkened and may rarely be almost jet-black Add a drop or two of bromine (or bromine water) to bleach this, and drive off the excess by gentle boiling When the odour is no longer perceptible in the steam, cool and dilute to 500 c.c This solution keeps very

well, occasionally showing slight darkening with age, which is of no significance.

(vii) 20 *per cent. lithium sulphate solution.*

Procedure Take 2 to 3 c.c. of fluorided or oxalated blood and centrifuge.

1 c c of plasma is placed in a small flask. Add 7 volumes of water, 1 c.c of 10 per cent. sodium tungstate, and finally, with shaking,

1 c.c of N/10 sulphuric acid. Filter off the precipitated protein

Into a tube marked at the 13-c c level place 5 c c. of the clear filtrate, and into a similar tube place 5 c c. of the dilute working standard (solution iv).

To each of these tubes add 2 c c. of water and three drops of 20 per cent lithium sulphate (solution vii). Mix and add to each 1 c c of uric acid reagent (solution vi) Mix.

From a burette add to each tube 2 c.c. of 15 per cent. cyanide solution (solution v) Mix. Allow to stand for two minutes, and then place both tubes in a boiling-water bath for exactly one minute Transfer to cold water, dilute promptly to the 13-c.c. mark, mix, and compare in a colorimeter. If there is any difficulty in obtaining a precise match, the use of an Ilford Micro 5 filter (furniture-red) will help greatly, but a slightly less dense orange filter may be even better. The writer gets the best results with two layers of orange celluloid from a car fog-lamp screen, cemented between discs of glass

The calculation is easy if it is remembered that the standard represents 4 milligrams of uric acid per 100 c.c. Thus

$$\text{blood uric acid} = 4 \times \frac{\text{reading of standard}}{\text{reading of unknown}}.$$

In order to correct for deviations from Beer's Law a second standard may be used if desired, usually prepared by using 3 c.c of the working standard and making up to 5 c c. with water, but other dilutions may be prepared if desired, and the standard chosen that approaches nearest to the unknown One or two minor difficulties may be encountered One of these is the occurrence of heavy white precipitates in the final tubes. The occurrence of these is peculiarly capricious, and seems most common when the cyanide solution is old or very new These precipitates are easily removed by centrifuging, and as they do not carry any colour down with them they give no appreciable trouble. Such precipitates often do not occur for months at a time. The use of an excess of potassium oxalate as an anticoagulant seems to encourage them. When the cyanide is old, the blue colour in the final tubes is weaker than when it is fresh, but as all the tubes are equally affected this does not matter

The method does not lend itself well to use as a micro-method, as when small quantities are used the one minute in the boiling-water bath seems to be too long and the colours may show a weakening and greenish discoloration A proportionally less period should be

Folin's Isolation Method

Solutions as described above for direct method and also·

(i) *Acid silver solution.*

5 c c of 85 per cent lactic acid, 100 c c. of water and 5 grams of sodium carbonate Boil

Dissolve 25 grams of silver nitrate in about 700 c c. of water and add the above lactic-acid mixture Dilute to 1 litre The solution keeps well, but is best filtered before use

(ii) 10 *per cent sodium chloride solution in N/10 hydrochloric acid*

Procedure Take 5 c c of the tungstic-acid blood filtrate and add 2 c c of the acid silver solution The uric acid is precipitated quantitatively Centrifuge and decant supernatant fluid as thoroughly as possible Add 1 c c of the 10 per cent sodium chloride solution in N/10 hydrochloric acid and break up the precipitate with a fine glass rod Add 4 c c of water and stir again. Centrifuge and transfer the supernatant fluid into one of the marked tubes as used in the direct method, 5 c c of standard being placed in another

The further procedure is as in the direct method described above

Better results are claimed by Brown (1945) for the following modification of the direct method

Solutions

(i) 12 *per cent sodium cyanide in water*
(ii) 50 *per cent urea solution*
(iii) *Uric acid reagent* prepared as follows

Dissolve with heat 100 grams of sodium tungstate and 20 grams of Na_2HPo_4 in 150 c c of water Mix 25 c c of concentrated sulphuric acid with 75 c c water, and pour the warm solution gently, with shaking, into the flask containing the tungstate Boil gently with a reflux condenser for one hour Cool and dilute to 1 litre

(iv) *Standard uric acid* 2 5 milligram per 100 c c
(v) *Working standard* Dilute solution (iv) 1 in 10

Procedure Place 2 c c of tungstic blood filtrate in tube graduated at 10 c c , add 2 c c. of 12 per cent cyanide (solution i) and 2 c.c of 50 per cent urea (solution ii)

[illegible]

(solution v) in a similar manner to the unknown

There is no apparent reason why this method should not be applied to the Folin Isolation Method after the precipitation of the uric acid by acid silver lactate

Uricase Method (Blauch and Koch, 1939)

Principle the estimation is carried out by a method resembling that of Folin, before and after destruction of the uric acid by uricase. The value obtained after such destruction represents the effect

produced by interfering substances Whether or not this method effects the purpose for which it is *intended is dependent* upon (i) the complete destruction of *all* the uric acid, and (ii) *no* destruction of any of the interfering *substances Whether, in* actual point of fact, both of these principles are achieved in practice is not completely clear.

Reagents

(i) 10 *per cent tungstate*

(ii) *N/12 sulphuric acid*

(iii) *Standard uric acid* 0·005 milligram per c.c. in lithium carbonate solution, preserved *with formalin*

(iv) *Uricase* —This is prepared from 1 lb of minced, defatted, frozen beef kidney *Dehydration is effected by means of four* 500-c c portions of acetone, each extraction being carried out for *twelve hours at 4° C Dry at room temperature with the help of a* fan, treat with two lots of 500 c c of benzene, the first lot for six *hours and the second for twelve hours Dry at room-temperature,* grind the tissue to 60-mesh size, and store in a desiccator at 4° C

(v) 2·5 *per cent sodium cyanide* in 25 per cent. w/v urea solution

(vi) *Uric acid reagent 100* grams of sodium *tungstate in 700 c c.* of water, to which is added 75 c c of 85 per cent. phosphoric acid. Boil with a reflux condenser for *twenty-four hours.* (The reason for this long period is not clear.) Decolorise as in the case of the Folin reagent with bromine or with *30* volume hydrogen *peroxide. Boil* ten minutes to drive off the bromine, cool, and dilute to 1 litre

Procedure To 2 c c of blood add 2 c.c of 10 per cent sodium tungstate and 16 c c of N/12 sulphuric acid Filter off the precipitated proteins

A similar precipitation is carried out on a second sample after incubation with the uricase For this purpose, 2 c.c. of blood are incubated at 40° to 48° C for two hours with 50 milligrams of uricase. The blood proteins and uricase are then precipitated by the same method as that used for the untreated sample of blood.

1 to 5 c.c samples of the uricase-treated and untreated filtrates are taken, and simultaneously standards containing 1 to 5 c c. of uric acid solution (0 005 milligram per c.c) are set up. Make up the volume of each tube to 5 c c with water, add 5 c c of sodium cyanide solution from a long-tipped burette, followed by 1 c.c. of uric acid reagent Mix, stopper, and allow to stand for three hours. Compare in colorimeter Subtract the value obtained after treatment with uricase from that obtained from the untreated specimen.

The authors employ a table to correct for deviations *from Beer's* Law. In view of the multiple standards, this seems hardly necessary.

It will thus be seen that the method takes at *least five hours* to carry out, and it is not clear why the ordinary Folin's Direct Method of estimation should not do equally well both before and after treatment with uricase. This would reduce the time needed to about two and a half hours, which is *a consideration in a busy* laboratory.

Glucose Metabolism

It was first shown by Pemberton (1926) that in true rheumatoid arthritis the glucose metabolism, as demonstrated by the glucose-tolerance test, is markedly altered This was amply confirmed by the present writer in 1931 The phenomenon is often quite striking, and may be used as a diagnostic criterion

The procedure usually adopted is to give a dose of 50 grams of glucose to the fasting patient and remove specimens of blood from a vein at intervals of ½ hour up to the end of 2½ hours In a normal person the blood sugar rises from a normal of about 0 075 per cent to a maximum not exceeding 0 16 per cent, usually at the end of the first ½ hour, though with slow gastric emptying this may occur in the next specimen At the end of 2½ hours the blood sugar has returned to normal

In rheumatoid arthritis, on the other hand, the blood sugar rises from the normal value sharply to a maximum that may be as high as 0 300 per cent and is usually over 0 200 per cent, but it returns to the normal base line (or possibly slightly over) at the end of 2½ hours The curve thus does not resemble that in diabetes, as the return to the base line is effected normally It does, however resemble the glucose tolerance found in many cases of exophthalmic goitre and hyperthyroidism generally, though the maximum values in rheumatoid arthritis may be higher than those in thyroid excess. A further distinction between rheumatoid arthritis and diabetes is afforded by the glycosuria during the glucose-tolerance test In diabetes, though the threshold may be raised, glycosuria is always marked, while in rheumatoid arthritis the renal threshold seems to be raised even higher, as it is exceptional to find more than a trace of glucose in the urine even after blood-sugar values of 0 300 per cent have been attained

The cause of this peculiar response to glucose is obscure The writer carried out an elaborate investigation of the differences between the arterial and venous glucose during the glucose-tolerance test with the idea that it might be possible to demonstrate a failure of the tissues to use glucose (Shackle and Copeman, 1933) Simultaneous specimens were collected of venous and capillary blood, and the blood-sugar curves plotted The results obtained, however, were largely fortuitous, normal persons often showing small difference between the two curves (though a difference in levels of 25 milligrams per 100 c c is common), and the reading of the results was rendered more difficult by the tendency of the venous peak to appear later than the capillary It would seem advisable, however, when reporting the result of a glucose-tolerance test to mention whether the blood specimens are venous or arterial For all ordinary purposes, capillary blood may be regarded as arterial

Bacteriological Investigations

(1) *Wassermann and Kahn tests* —These are clearly indicated in cases where a Charcot's joint, a gummatous synovitis, or symmetrical effusions into the knee joints make syphilis a possibility

The technique of the Wassermann reaction has been much improved and stabilised of late years It is unfortunate that there is *still* no single really stable standardising factor in the test Known positive and negative sera are still needed as a check on the test, and the paucity of the former in laboratories devoted to the study of rheumatism makes it very hard to carry out the test satisfactorily.

The Kahn test, on the other hand, if properly carried out by someone experienced in reading the results, is very reliable, and is probably sufficient for all ordinary purposes.

(ii) *Gonococcal complement fixation test.*—This test has proved disappointing in our hands, in spite of a careful standard technique. When positive results are obtained, they are nearly always in cases where there is a persisting gleet (these cases are uncommon at the present day), or where there is gonococcal pus, probably under pressure, in some closed cavity such as a knee or Fallopian tube.

(iii) *Agglutination tests*—Numerous attempts have been made by various observers to incriminate various organisms (mostly hæmolytic streptococci) by testing the power of the patient's serum to agglutinate them The results to date have been singularly unconvincing, and the anti-hæmolysin titration test has given such erratic results that no reliance can be placed on them. With any of these tests, a positive result does not, of course, necessarily mean that the organism in question is causing the rheumatism

(iv) *Search for septic foci*—The search for septic foci, at one time regarded as so essential in many diseases, is now under a cloud in rheumatic diseases as well as in others Nearly all rheumatic cases at one time had their teeth removed on the smallest excuse, and often their tonsils as well The fact that they sometimes had a "flare-up" of the affected joints was regarded as indicating that the foci had been found, but there is always the possibility that this was a non-specific reaction, and in few cases could it be proved that the disease was in any way interrupted by the removal It seems highly probable that the patients would have been no worse (and they certainly would have been happier) if their teeth had been left in Cultivation of tooth apices and of tonsils either before or after removal seldom gives any illuminating results. Substantially the same growths of organisms are obtained as from normal persons In cultivating tooth apices it is, of course, especially difficult to avoid contamination with mouth organisms, even when special precautions are taken and when the planting on artificial media is made at once on removal of the tooth Such contamination nearly always occurs during the preliminary rocking of the tooth, and the only safe procedure is to cultivate from the pulp cavity after sterilising the outside of the tooth This may be done by treating the outside of the tooth with spirit and splitting it longitudinally with bone forceps

Vaccines, both autogenous and stock, have been used extensively in the treatment of rheumatism but with disappointing results.

Other Tests

(i) *Serum colloidal gold* —Following on the observation of MacLagan that cases of rheumatoid arthritis show a positive colloidal gold test when this is carried out on the patient's serum, and the suggestion of Coke (personal communication) that the test affords a means of differentiating between rheumatoid arthritis and other forms of rheumatism, some work is being carried out by the writer along this line, but it is as yet too early to pronounce on the results

(ii) *Protein sensitisation* —A theory that seems to deserve further investigation is that rheumatic cases of various types may be in some way sensitised to some substance, possibly a bacterial protein, the organism in question being possibly non pathogenic under ordinary circumstances

Intradermal testing has not so far been very helpful, but this may merely mean that the correct protein has not been found

(iii) *Cutaneous trichophytides* —Epidemics of ringworm of the toes (euphemistically called Athlete's Foot) unluckily appear from time [illegible]

their attendance as soon as possible to avoid contamination of the floors Even a normal person with crowded toes may show some [illegible] the immersion involved [illegible] e so little irritation that [illegible] e difficult [illegible] roscopically These are removed with forceps, preferably from the margin of the lesion, or, if no such scales are available, some scrapings may be made with the edge of a glass slide It is important that the skin should be dry and free from ointments If the latter have been used, the patient should be referred for a day or two and then re examined A number of scales should be removed, as it is remarkable how often an active case may show mycelia in only one scale out of a dozen or more.

There are various methods of examining these scales, of which the simplest is probably the best

The scale is placed on a slide with a drop of 5 per cent potassium hydroxide Place a cover glass over it and warm it gently over the by-pass of a bunsen burner Press gently on the cover-glass If the procedure is successful the scale becomes glassy clear Examine with a one-sixth-inch objective and lowered condenser, when the characteristic filaments may be seen, often resembling the map of a river There are various pitfalls for the unwary, notably the occurrence of a "mosaic" of fatty-acid crystals which may resemble coarse ramifying mycelia If the condenser is lowered too much the cell outlines may confuse the beginner

Modified Gram's Method —The scales are first defatted by passage through alcohol to ether, brought back to gentian-violet solution, passed through Gram's iodine and decolorised with a mixture of aniline and nitric acid This procedure is best carried out on a special tile furnished with small shallow wells in which the reagents

are placed. The difficulty of recovering the scales intact from ea reagent with a platinum loop may be imagined, especially when tl reagent is opaque, as in the case of gentian violet. All the reagen must, of course, be rejected after each batch from one case ha passed through, to avoid the risk of scales or parts of them being le behind to add themselves to the next batch. It may be wise to carr out the decolorisation under the microscope. The filaments shoul appear Gram-positive

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(iv) *Joint fluids*.—The characters of these have been dealt witl so thoroughly elsewhere in this book that it is not proposed to discus them here. It may, however, be mentioned that the investigation of their cytology presents special difficulties, as the cells, presumably from long sojourn in the joint, are usually highly degenerate, and *their positive identification is usually easy only in the more active* conditions where the cell counts are higher and the cells clearly more recent

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as it halves the life of his X-ray tube and doubles the expense of his department

The clue to the nature of a lesion in a major joint is often found in a minor joint, the converse is less often true It has been the custom at the British Red Cross Clinic for Rheumatism to ask for a radiograph of a hand in atypical cases The reasons for this are three—the hands are sites of election, it is easy to secure good radiographs and assess the calcium content of the bones, and there are so many joints visible on the film The diagnosis is easy in straightforward cases, it is difficult in

(*a*) The very early lesions which may not have developed diagnostic features
(*b*) Atypical conditions
(*c*) The very advanced disease in which joints are disorganised
(*d*) The mixed arthritides

Rheumatoid Arthritis

The radiological diagnosis may be attempted on the films of either a major or minor joint In cases of doubt it is always advisable to wait for a film of the hand or hands before making the diagnosis

The relative incidence of the disease in the various joints is fairly constant The small joints of the hand and wrist are most commonly affected The feet are also frequently involved and there is a progressive and rapid decline in incidence in the more proximal joints [illegible]

appearance of decalcification by over-penetration and sclerosis by under-penetration The examiner who recognises some fault on the film must make a mental adjustment to compensate for it, or have the examination done again In early cases the radiologist has to depend on the recognition of decalcification, as there may be no other features to assist him Having detected the osteoporosis, it is necessary for the radiologist to remember that other lesions also produce similar appearances—for example, disuse, senility, Sudeck's atrophy and metabolic diseases [illegible]

[illegible] report of rheumatoid arthritis on the presence of *early decalcification* alone It is justifiable to say that the appearances are compatible with early rheumatoid arthritis and ask for a later film

If two films of an active rheumatoid arthritis are examined, one at the inception of the disease and one approximately three years later, it will be noticed that, in the latter, the cancellous bone is less clearly defined, that there appears to be less cancellous structure than before, and the small spaces between trabeculæ are more opaque, as if calcium had been washed out of the trabeculæ into the

CHAPTER IX

RADIOLOGY IN ARTHRITIS

THE radiological problems in rheumatism can be very difficult, but these difficulties do not arise if the radiologist is content with a simple classification

The simplest division for radiological purpose is—rheumatoid arthritis, osteoarthritis and gout, but any radiologist who has seen many patients with *rheumatoid and osteoarthritis must notice*

that it taxes all resources, but it would be a great advance if subtypes could be demonstrated The radiological diagnosis and differential diagnosis is based on seven factors.

(1) Alteration in calcium content
(2) Loss of cartilage.
(3) Erosive change
(4) New bone formation
(5) Subluxation and dislocation
(6) Ankylosis
(7) Formation of loose bodies

The diagnosis depends upon the time of appearance and the type of these changes, for example, the erosion may be smooth or irregular; it may be superficial or deep, it may be marginal or generalised, and may be in characteristic situations in certain joints

The radiologist who bases his diagnosis on these features will not have great difficulty in classifying arthritis into the three simple forms mentioned, but the next step, the subdivision of these, is much more difficult If it were possible to do this in all cases, and at an early stage of the disease, it would still not justify a classification of rheumatism on radiological grounds alone This can be demonstrated by the fact that certain lesions remain periarticular throughout their course and gouty deposits are not always in bone, the radiologist is not given any means of recognising these lesions It may be added that not all periarticular conditions are gouty. The diagnosis may often be made on one small typical feature in one film which serves as an index to the remainder. It is fortunate for the radiologist that many joints are often affected. It is a wise principle to have films of several joints in difficult cases, but it is extremely expensive if this principle is applied to all affected joints as the first step in investigation It is also a confession of ignorance of the normal, to radiograph the affected joint and the normal on the opposite side The radiologist is always concerned by this request,

as it halves the life of his X-ray tube and doubles the expense of his department

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The relative incidence of the disease in the various joints is fairly constant The small joints of the hand and wrist are most commonly affected The feet are also frequently involved and there is a progressive and rapid decline in incidence in the more proximal joints A radiologist working in a busy department may see only one patient in a year with rheumatoid changes in the shoulder or hip

It is for rheumatoid arthritis that a real attempt at standardisation of the technique is required The careless technician can produce an appearance of decalcification by over-penetration and sclerosis by under-penetration The examiner who recognises some fault on the film must make a mental adjustment to compensate for it, or have the examination done again In early cases the radiologist has to depend on the recognition of decalcification, as there may be no other features to assist him Having detected the osteoporosis, it is necessary for the radiologist to remember that other lesions also produce similar appearances—for example, disuse, senility, Sudeck's atrophy and metabolic diseases such as
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spaces between the network. These features are more easily observed with a magnifying glass The degree of osteoporosis throughout the course of the disease will also be found to be a coarse measure of the activity of the condition The clinician has other and probably better means of assessing activity, but it will be found that osteo-

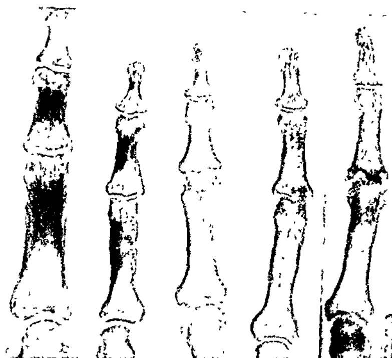


FIG 44 FIG 45 FIG 46 FIG 47 FIG. 48

FIG 44—Intense osteoporosis near the joints

FIG 45—Osteoporosis with commencing marginal erosion of the base of the proximal phalanx

FIG 46—Next stage of marginal erosion of metacarpo phalangeal joint

FIG 47—Erosive change in the proximal interphalangeal joint with cartilage loss

FIG 48—Erosive change spreading across the joint surfaces of the metacarpo-phalangeal and proximal interphalangeal joint.

porosis increases with the march of symptoms and that calcium returns with remissions and quiescence This return of calcium is seen as an increased density of the trabeculæ with clearing of the spaces between the network, and an improved definition of the cortex of the articular surface, although the irregularity of earlier erosions on this surface still persists

Surface erosion, particularly marginal erosion, is a typical finding, it occurs about the same time as, or sometimes before, *cartilage loss*. This erosive change is not associated with a local sclerosis, it may spread to involve the whole surface and may also simulate gouty



Fig 49 Fig 50



Fig 51



Fig 52



Fig. 53

Fig 49 —Marginal erosion spreading down the meta carpal head with subluxation
Fig 50 —Dislocation without erosion
Fig 51 —Smooth erosion simulating gout
Fig 52 —Similar change but resemblance to gout is less marked
Fig 53 —More extensive erosion simulating gout

change, particularly when it has been present for a long time. The *edges of an early erosion are* quite irregular, whereas old erosions tend to become smooth and sharply defined, like gouty deposits Typical *sites for gouty deposits are the distal* and proximal ends of the metacarpal of the thumb. The best examples of marginal erosion are seen in the phalangeal joints (see Figs. 45, 46, 47). Extensive surface erosion may give two results—either the irregularities of neighbouring surfaces fit in to one another, giving a mortised or dentate effect, or the surfaces become so irregular from partial absorption of bone that the joint is subluxated or dislocated. The dentate effect is not *seen in the metacarpo-phalangeal* joints, but this is the common site for *subluxation.* This dentate appearance is not confined to rheumatoid arthritis but may also be seen in osteoarthritis. No difficulty will be found in differentiating the two as the other features are so dissimilar. Erosive change of the heads of the 2nd to 5th metacarpals frequently *extends for some distance proximally,* particularly down the lateral side of the head, and it appears that these must be extra-articular, that is beyond the capsule (see Figs 49, 50)



Figs 54, 55, 56
Three stages of rheumatoid arthritis in the carpus

Most infective joint lesions tend to form new bone, often at an early stage, and particularly in the healing phase, but this is not a prominent feature of low-grade infections or rheumatoid arthritis; and the absence of this feature may be used in differentiating this lesion from others which resemble it These lesions may, however, heal by *ankylosis*, a spontaneous cure of the carpal lesion of rheumatoid arthritis by ankylosis is quite common in the absence of immobilisation Before ankylosis can take place the cartilage must be destroyed and the cortex eroded. Fusion of the bones is often complete and the total area of the carpus *is much reduced.* Ankylosis of the other minor joints *of the hand and any* major joint is extremely rare. At this stage the radiologist may note the signs of quiescence previously mentioned. but I have observed that the

B S R is still raised and the radiologist is permitted to wonder whether any patient who has had a raised sedimentation rate for any period, associated with a marked rheumatoid arthritis, ever regains the normal sedimentation values The explanation presumably is that those who have recovered do not attend his department

The radiological diagnosis of rheumatoid arthritis of the major joints is often difficult The alterations from the normal are similar to those described in the minor joints The absence of subchondral sclerosis and new bone formation are important negative features The radiological changes are usually not in proportion to the physical deformity or complaint, and sometimes they bear a close resemblance to tuberculosis The saving factor in many instances is the multiple joint involvement

After many years, a rheumatoid joint may show some marginal lipping, particularly in the lower limbs, but it is then in the category of a mixed arthritis with a superadded osteoarthritis The new bone is only the response to the mechanical imperfections of the joint

Non-specific Infective Arthritis *

The *relationship of this lesion to rheumatoid arthritis is not* known It is unlikely that this relationship will be more defined until more is known of rheumatoid arthritis The radiological appearance of the lesion resembles rheumatoid arthritis closely in the early stages. Fewer joints are affected, however, and often only one joint Resembling rheumatoid arthritis there is a tendency to symmetrical distribution, but it is more striking radiologically when only one joint is involved on each side The earliest evidence of involvement is usually cartilage loss without the cortical erosion so typical of rheumatoid arthritis The erosions of articular surfaces may cause considerable absorption of bone and some sclerosis becomes evident (see Figs 57, 58, 59) Sometimes a pseudocystic change extends for some distance beyond the articular surface Some of the most typical lesions are found in the carpus, the affected bones are increased in density with cartilage loss and pseudocystic change extending into the radius In moderately advanced lesions there is a definite and often very marked sclerosis of the affected bones It extends deeply in subcortical bone and is accompanied by new bone formation on joint margins Both these features are quite unlike the ordinary rheumatoid change A few of the affected joints show a slight periosteal reaction of the shafts above or below the arthritis (Figs 58, 59) This may appear during the stage of osteoporosis before there is any evidence of cartilage loss or erosion

Osteoarthritis

The diagnosis of osteoarthritis is as simple as any which the radiologist has to make The various features of the condition are

* The special features mentioned as characteristic of this syndrome have not so far made it possible to pick out these cases clinically they are included in other sections of the book under the generic title Rheumatoid Arthritis [Ed]



Fig 57



Fig 58



Fig. 59

Figs. 57–59 —Non-specific infective lesions showing the considerable cartilage loss and marked sclerosis of subarticular bone

usually so well defined that confusion with other diseases is unlikely, one exception is the early Charcot's joint

In some films the evidence of previous trauma, congenital abnormality, adolescent deformity, or infection may still be visible The osteoarthritis is engrafted on this abnormality It is then not uncommon for the whole condition to be labelled osteoarthritis Examples of this are seen in the adult with some degree of congenital dislocation of the hip and in the condition of arthrokatadysis or *prostusio acetabuli, the latter is frequently called osteoarthritic* protrusion of the acetabulum, but the osteoarthritis is in no way responsible for the protrusion

A concise and accurate radiological classification of osteoarthritis is not easy, since the responsibility of predisposing factors is difficult to apportion Three of these factors are low-grade sepsis, senile degeneration and aseptic necrosis The joint in which this difficulty is manifest is the hip in the later age-groups It is also known that strain and weight-bearing functions are potent factors and may influence the appearance of the joint all through the course of the disease The influence of strain is noticeable in the younger patient osteoarthritis is liable to commence early and be the terminal result in any joint forced to bear undue strain This strain may be contributed by mechanical imperfection, the result of previous deformity, or coexistent disease in other parts outside the joint—e g a scoliosis resulting from an empyema may produce osteoarthritic lipping on the concavity of the spine Some factors are

(1) *Congenital deformities* especially congenital dislocation of the hip, also congenital coxa vara

(2) *Infantile and adolescent deformities* osteochondritis and osteochondritis dissecans, slipped femoral epiphysis, static lesions

(3) *Adult deformity* · (*a*) result of trauma with subluxation dislocation or fracture, (*b*) result of trauma or disease of opposite limb with a defective gait, (*c*) engrafted on an infective arthritis which may be specific or non specific

These groups may be classified as secondary osteoarthritis The onset appears to depend on the degree of deformity and the cases of osteoarthritis in the comparatively young patient can be traced to this group. Apart from these types there are the degenerative lesions—the morbus senilis, in which the incidence increases progressively with age. In many instances some factor from the first series may play a part, for instance trauma, but many cases appear to be purely degenerative in origin and these cases can be called *primary osteoarthritis. It is in this series that predisposing factors* are difficult to assess The radiological evidence may be insufficient or confusing It is a fact that the mode of onset in osteoarthritis and the progressive changes are not the same in all patients It appears, therefore, that different factors are at work *This is* again demonstrated in osteoarthritis of the hip For example, the onset of osteoarthritis in this joint may be shown by the loss of the cartilage, by the formation of the new bone and by subchondral changes in the bone One of these features may be the

and the 1st carpo-metacarpal joint (Figs. 61, 64) The displacement consists of a lateral or medial shift of the terminal phalanx on the middle phalanx. It is very difficult to assess the relative importance of the various factors which may initiate the displacement. Many joints progress to crippling deformity without subluxation. Subluxation of the hip joint is common It is an important complication, as it appears to be difficult to check and impossible to correct I have never seen a film showing subluxation which was afterwards reduced as the result of treatment. The mechanical efficiency of the joint must be reduced by this displacement and this, no doubt, stimulates further osteoarthritic changes The subluxation is seen on the film as an outward displacement of the femoral head; at the same time a crescent-shaped deposit of bone forms in the acetabulum, in the site previously occupied by the head. It is not possible to determine radiologically whether the head moves out and is replaced by this bone or whether the bone forms and pushes the head laterally. In the moderately advanced disease the outer half of the acetabulum now becomes deformed, the roof is flattened, or even directed outwards with some upward displacement of the femoral head

Cavitation.—A peculiar feature of osteoarthritis in certain situations is cavitation of bone It is a reasonable supposition that these cavities are the result of defective nutrition of slow onset The best examples of this condition are seen in the hip joint At operation they consist of pseudocystic areas They are found in both the femoral head and acetabulum Very large cavities are found in the acetabulum and these may cause an error in diagnosis, especially the presence of a single cavity On the film the lesion is represented by a dark circular area which may be as large as a half-crown An error will not be made if the possibility of very large cavities is known and other evidence of osteoarthritis is recognised in the joint this is usually present at this time It should also be recognised that cavitation of bone is *sometimes* the first and only evidence of early osteoarthritis

Cavitation is rare in other joints It may occasionally be seen in the patella and elsewhere. It is more common than is generally recognised in the shoulder joint In this region the cavities are very small and less numerous than in the hip Pitting of the head of the humerus is quite common in osteoarthritis of the shoulder It is usually ignored, but it is frequently the only evidence of osteoarthritis of this joint. New bone formation or other osteoarthritic changes are quite rare Osteoarthritic signs are common in the acromioclavicular joint They are present so often in films of supposed osteoarthritis of the shoulder that many radiologists must have wondered whether the clinician was tracing the symptoms to the responsible joint.

Sclerosis of subarticular bone is a common feature It is constantly found in the hip joint when the disease is moderately advanced. It is always associated with cartilage loss and other features of osteoarthritis are usually present. It extends fairly deeply in the

acetabulum and also involves the femoral head. The distribution of the sclerosis corresponds with the areas of cavitation and both are frequently present in the same patient

The distal end of the carpal scaphoid articulates with the multangulum major and minor, sclerosis of the surfaces of this articulation is common in osteoarthritis, the sclerosis is often extremely dense; it is accompanied by loss of cartilage, but there may be no other evidence of osteoarthritis in the carpus The sclerosis of bone, particularly that type found in the acetabulum, may be put forward as evidence that the major factor in causation of osteoarthritis is defective nutrition



Fig 67
Aseptic necrosis of the femoral head following fracture

There are also other features in the X-ray appearance and clinical course of osteoarthritis that are found in aseptic necrosis (Fig. 67) If it is assumed that the ætiology of these conditions is the same, it is difficult to explain the extensive changes in the acetabulum in osteoarthritis It is known that the blood supply of the femoral head is not good and facilities for a secondary circulation are lacking In order to explain the radiological appearances in the acetabulum it must be assumed that the blood supply to this region is also restricted since the changes extend deeply in the bone and are not secondary to the condition of the femoral head It is probable that a defective blood supply is the true explanation in the acetabulum, but it is difficult to prove

Alteration in shape of articular surface —The hip joint is again the site of a deformity which is rarely found elsewhere The femoral head becomes flattened and there may be some varus The femoral neck also becomes thickened by organisation of subperiosteal bone mainly on the medial side of the neck The end result simulates the deformity of late Perthe's Disease or slipped epiphysis and may lead the examiner to believe erroneously that the patient has suffered from one of these conditions in the past

Gout

The radiological diagnosis depends upon the fact that sodium biurate is deposited in the bones and that these deposits are not opaque to X-rays The deposit appears as a cavity in the bone, the walls of which are smooth and denser than normal, the clear definition

of the deposit is a characteristic feature. These deposits give a punched-out appearance in the phalanges and metacarpals and a spotty appearance in the carpals—as they are not usually seen in profile

The situation of the deposits is another feature of the disease. They are *frequently on the margin of the articular surface* or some distance from it and less often on the surface of the joint A careful

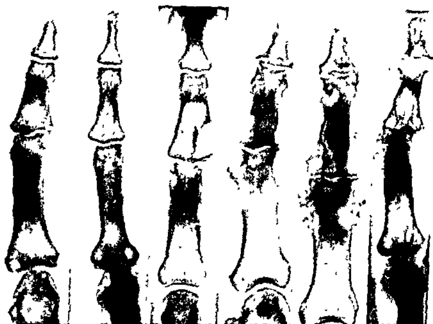


FIG 68 FIG 69 FIG 70 FIG 71 FIG 72 FIG 73

FIGS. 68-73 —Gouty deposits in various stages

examination of the films will demonstrate that many deposits, particularly in the advanced lesions, are outside the capsule of the joint. *A soft-tissue swelling is often visible on the film at the site of* a deposit and it is necessary to remember that the radiological *diagnosis of gout cannot be made if deposits are in soft tissue, but not* in bone It has been mentioned before that a deposit at the ends of the Ist metacarpal is very common Destruction of cartilage is not an early feature of the condition. The joint is narrowed earlier when there are tophi on the articular surface, it is preserved or only slightly narrowed in many cases with very large deposits when these are marginal or beyond the joint surfaces. Calcification in the tophus is very rare, the calcium appears as dense homogeneous flecks in soft tissue and the bony lesions are usually advanced Some *advanced cases of gouty arthritis display a superficial resemblance* to multiple chondromata and some early lesions have a close re*semblance to rheumatoid arthritis An important differentiating* feature is that rheumatoid arthritis frequently causes osteoporosis

but gout never does. The lesions of gout in a major joint seldom bear diagnostic features, and the diagnosis is rarely made in the X-ray



Fig 74

Gouty deposits in the carpus

department. The diagnosis is also difficult in those patients with gouty symptoms without frank arthritic changes In both instances a diagnosis of gout may occasionally be made by finding typical gouty erosions in the hand, even in the absence of clinical signs or symptoms in these parts



Fig 75

Boecks Sarcoid Note the central deposits and the pseudo cystic appearance of the terminal phalanx which is unlike gout

Spondylitis Ankylopoietica

The diagnosis of ankylosing spondylitis, once the spine shows calcification of ligaments, is easy. It is only necessary to differentiate between calcified ligaments and the osteophytic outgrowths of osteoarthritis The age of the patient is often all that need be known to differentiate the two conditions As in rheumatoid arthritis there are gaps in our accumulated knowledge which have not been filled It has been shown, and not seriously disputed, that the earliest lesion is in the sacro-iliac joints Some of the unanswered questions might be

(1) What percentage of the sacro-iliac infections progress to spinal involvement?
(2) In a lesion which has all the appearances of an infection (in sacro iliac joints), why are both joints so often affected simultaneously? If it is denied that the lesion is infective in origin, then it is remarkable that the differentiation from another known infection (tuberculosis) in this joint is made with the greatest difficulty
(3) Are there two types of sacro-iliac joint lesion, one of which precedes spondylitis and the other does not but remains

localised and accounts for the sclerosing lesions in this region?

(4) What is the explanation of the fact that some patients with sacro-iliac changes exhibit a very high sedimentation rate, whereas in others the rate is unaltered, although both types have the same radiological appearance?

In ankylosing spondylitis clinical symptoms and signs may often be found in many joints, but the radiological changes are usually confined to the sacro-iliacs, the intervertebral facets, the costo-transverse, the costovertebral and hip joints. Clinical signs in the smaller joints may only show radiologically as a speckled osteoporosis of the bones, if erosion takes place, then it resembles that of rheumatoid arthritis very closely In addition to these features there is sometimes a peculiar erosion followed by calcification of ligaments which obliterates the pubic symphysis and a superficial osteitis with condensation and irregularity of the cortex of the tuber ischii and inferior surface of the os calcis.

The sacro-iliac joint disease is nearly always bilateral at the first examination, it may be more advanced on one side and careful examination is sometimes necessary to detect the bilateral lesion *In a few cases it is unilateral and remains so. In order to detect the* earliest manifestations of involvement, all the refinements of expert radiography are required These early changes consist of an irregularity of the articular surfaces due to an erosive change which is comparatively superficial Later the white line of the articular surface disappears, the erosive change then extends for a short distance in subarticular bone This extension is limited or defined by a zone of sclerosis, this sclerosis is a useful diagnostic feature since it removes any doubt that the joint is involved The course of the lesion now depends upon the activity of the process. Some lesions remain stationary for a long period, others progress In either case, alteration of the radiological picture is a slow process It is usually necessary to wait six months before a useful opinion can be expressed

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strated in the intervertebral ligaments or facets. The calcification of ligaments is described in the chapter on Spondylitis Ankylopoietica

Differential Diagnosis

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may have caused symptoms which resemble rheumatism, particularly pain Syphilis and tumours are examples of such diseases

Syphilis

The X-ray appearance of a Charcot's joint may resemble osteoarthritis very closely This is a very real difficulty in the early Charcot's joint but not many early cases are seen in any X-ray department The most useful feature in differentiating the condition is the presence of some subluxation of the joint This may be only slight in degree but it should impress the examiner as it is not a feature of early osteoarthritis except in the phalanges For example, the film of a knee may show an unusual width of the joint space on one side with a few loose bodies, the examiner should at once exclude syphilis, especially if there is any sclerosis of subarticular bone In the moderately advanced disease these three features—subluxation, sclerosis and new bone formation—are increased, particularly the latter, and it should be noted that this bone may extend beyond the joint

[illegible]

trabeculation of the medulla is disorganised. As a result of persistent periostitis the shaft may increase in width by organisation of periosteal layers and as these layers vary in width the outline of the shaft becomes uneven Occasionally the osteitis of the shaft extends to the end of the bone and involves the joint The patient may then present clinical and radiographic evidence simulating a rheumatic joint, the radiological clue to the origin of the symptoms is the recognition of the fact that the disease is primarily in the shaft of the bone and the involvement of the joint is a direct spread

Tumours

Primary growths and secondary deposits are recurring features in an X-ray department The primary tumours are frequently deeply situated and they are less common than the secondaries The latter are the usual osteoplastic and osteolytic forms The osteoplastic type is relatively but not absolutely more common, as the primary growth which supplies these secondaries may easily escape in a clinical examination

Paget's Disease

Paget's Disease is usually painless and many cases are found in routine examinations without symptoms referable to the affected region Three varieties of lesion may cause pain These are—the vertebral involvement with collapse of a body, the Paget's Disease which becomes sarcomatous, and the type which affects the hip joint and causes arthritis The sarcomatous degeneration in Paget's Disease is readily recognised if the possibility of such a change has

not been forgotten; it is almost invariably an osteolytic lesion and is common at the lower end of the femur.

The arthritis of Paget's Disease is not often described. It is almost confined to weight-bearing joints and is most commonly found in the hip Both the acetabulum and the femoral head are usually affected before arthritic change occurs. The femoral head may be *enlarged and flattened with a coxa vara* The cartilage space is narrowed as in osteoarthritis. The condition may cause considerable pain

Tuberculosis

The age incidence of joint tuberculosis is below that of rheumatism, except for Still's Disease. There is no similarity between the ordinary



Fig 76

Tuberculosis of the carpus

case of osteoarthritis or gout, and tuberculosis. A real difficulty is the differentiation of tuberculosis and the solitary rheumatoid joint. It may happen that a definite *conclusion cannot be reached* on one radiological examination. Both lesions pass through the same stages of osteoporosis, cartilage loss and surface erosion The first information which the radiologist requires from the clinician is—how many joints are affected This information may at once exclude tuberculosis

The relative incidence in va

and rheumatism, the common

hip, knee, shoulder and elbow,

are rarely affected in the adult The type of tuberculous joint which resembles the rheumatoid or non-specific arthritis is the slowly *advancing and presumably less active disease The typical picture of*

joint tuberculosis is one of local osteoporosis with a vanishing cortex accompanied by subcortical erosion of varying degree (Fig 76) These erosions may assume a punched-out form with an ill-defined edge, and this feature may be almost diagnostic of tuberculosis, particularly in the shoulder and knee Sequestra form in tuberculosis but are never seen in rheumatism

Perthe's disease and slipped epiphysis may be mistaken for tuberculosis clinically, but they occur at a time when rheumatic lesions are rare in the hip joint They frequently lead to a deformity which predisposes to early osteoarthritis (see Osteoarthritis)

The radiological picture of *osteochondritis dissecans* is easily recognised The lesions may occur in the knee, elbow, ankle and hip, other joints are very rarely affected The most common site is the anterior aspect of the medial condyle of the femur in the young adult The film shows a saucer-shaped depression in the condyle This depression contains a segment of bone of increased density, which *may be fragmented, it is considerably smaller than its socket* At some time these fragments tend to be extruded and form loose bodies The condition usually follows trauma and the patient may be seen at any stage during the course of the lesion The *septic joint* is not often seen in the X-ray department The clinical history and signs are usually sufficient to rule out other possibilities The radiological course is rapid, with loss of cartilage over the whole articular surface in a few weeks Osteoporosis is intense, followed by subluxation and new bone formation, the latter occurs at a much earlier stage than is seen in any other lesion

The adult *form of a congenital* and *familial dystrophy* of cartilage and bone—Morquio's Disease, or chondro-osteodystrophy—may resemble rheumatic conditions There have, however, only been three of these patients in one rheumatic clinic in fifteen years The dystrophy of the cartilage of the epiphyses accounts for the joint deformities and the lesions bear some resemblance to osteochondritis The vertebræ are flattened (platyspondylia), the vertebral surfaces are irregular, and the disc spaces much narrowed.

F. CAMPBELL GOLDING

CHAPTER X

ÆTIOLOGY AND PATHOLOGY OF RHEUMATIC FEVER

Ætiology of Rheumatic Fever

DESPITE many years of intensive research, the ætiological problem of rheumatic fever still awaits solution. Certain predisposing causes are well known Climate appears to exert a profound influence upon the incidence of this disease, the tropics being relatively free, whilst the temperate zones show a high attack rate A positive family history is present in from 18–70 per cent according to a variety of authors Many clinicians testify as to the deleterious effects of damp, exposure and unaccustomed work under arduous conditions Copeman's experiences (1944) are interesting with regard to this last condition

Malnutrition has been considered by Rinehart (1943), especially with regard to vitamin C deficiency, and, though the evidence is not conclusive, few will deny that malnutrition is an important contributing factor in the production of this disease. The most striking predisposing cause appears to be poverty. Coburn gives the ratio of twenty poorer-class children to one better-class child in New York City. A similar ratio has been reported by numerous other workers, whilst Morris and Titmuss (1942) give an interesting survey of England Poverty acts through a combination of malnutrition, bad damp houses, and possibly greater opportunity for cross-infection The largest number of cases occurs in the late winter and spring, at a time during which bodily resistance is unusually low, and upper respiratory infections common

Many authors, including Alison Glover, have remarked on the declining incidence of rheumatic fever, and there is no doubt a very remarkable difference has appeared during the last twenty years

The clinical aspects of this disease—pyrexia, sweating, malaise, leucocytosis, hot swollen joints, and the cardiac lesions—have led many to believe that the problem was simply that of isolating the specific infective agent The search for an organism capable of fulfilling Koch's postulates has been unremitting, though fruitless up to the present time

It would be tedious to record the claims of many workers to have isolated the specific organism, Poynton and Pain's diplococcus enjoyed the greatest vogue, but even that has now been consigned to the limbo of the forgotten Many efforts to induce rheumatic fever in animals have been made, but the identity of the various lesions produced has never been proved It is possible that the histological reaction to the rheumatic stimulus may differ in man and animals, thus providing an explanation of this previous anomaly.

Riches and Gregory (1943) experimenting with serum sickness in rabbits noted in some cases cardiac lesions that closely resembled those of rheumatic carditis Boots and Swift (1923) examined synovial fluid from cases of rheumatic fever and from cases of serum sickness and concluded that the two were indistinguishable Rinehart *et al* (1934) reported that guinea-pigs on a vitamin C deficient diet infected with guinea-pig hæmolytic streptococci developed cardiac and articular lesions which they felt bore a very close resemblance to those found in rheumatic fever Some of the animals even produced subcutaneous nodules This work has been subject to considerable controversy, but the authors still maintain their contention

Numerous bacteria have been obtained by post-mortem examination of cases of rheumatic fever, but the careful technique of Green (1939) by which he grew hæmolytic streptococci from the heart valves but not the heart blood in eight out of nine cases, and the fact that these strains in the five cases tested were the same as found in the throat appeared convincing However, Angevine *et al* (1940) in a very careful investigation of twenty-two cases could not confirm these findings, whilst Swift (1944) is in agreement with this last author. Rantz *et al* (1945) regard the different strains of hæmolytic streptococci as a factor, and think that the reinfection with a *different strain* may take place in some cases of acute rheumatism This work will need confirmation, but introduces a new angle in this difficult subject and is of considerable interest

The failure to incriminate a bacterium led to the search for a virus, either as a direct infective agent or as a contributing factor. Schlesinger *et al* (1935) by the use of high-speed centrifugalisation obtained from rheumatic exudates particles morphologically similar to elementary bodies of known viruses Suspensions prepared from these particles were agglutinated by sera from patients suffering from rheumatic fever Suspensions of particles obtained from non-rheumatic sources were not agglutinated This evidence was suggestive and in line with the known behaviour of virus suspensions and immune serum This work was extended by Eagles, Evans, Fisher and Keith (1939), with confirmation of the original results and the additional information that these particles could be found in rheumatoid arthritis and chorea, though in a small proportion of cases Particles from non-rheumatic sources were not agglutinated by these means Further work by Eagles and Bradley whilst confirming the existence of this phenomenon in a significant number of cases was unable to establish its importance, as administration of the alleged virus by a number of different routes failed to infect rhesus monkeys This work is interesting and apparently the lack of definite infective properties should be explained in two ways Firstly, that the virus is present but is non-infectious owing to the animal being unsuitable Secondly, by analogy with certain other diseases, notably yellow fever The precipitinogen found in the serum of yellow-fever cases has been shown by infectivity tests not to be the virus, though it produced a specific reaction with yellow-fever sera

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The observations of Copeman (1944) are of interest in connection with the theory of direct infection This worker was able to observe a large body of soldiers stationed in the desert, and the appearance of forty-two *cases of rheumatic fever amongst them. Ten of these* cases gave histories of previous attacks, the shortest period of which was two years previously and the longest *fifteen years. Thirty-two* cases suffered a first attack The significant part of this survey was that except for crossing India fourteen months previously these patients had had no urban contacts for two years. The first case of rheumatic fever admitted to hospital was a first attack, and was the only case reported from the unit The possibilities available to explain these cases is either that the infectious agent is able to lie dormant for years, or that no specific infectious agent exists, the sync [illegible]

the [illegible]

with the disease, and certain other features have of recent years caused an increasing number of workers to believe that this disorder may eventually *prove to be a pattern-reaction to a variety of stimuli* Considerable evidence is now available to suggest that the hæmolytic streptococci play an important part in the production of rheumatic fever Coburn believes that heredity and environment combine to produce individuals who do not handle hæmolytic streptococcal infections in the normal manner It is believed that there is a slow or altered immune response to the primary infection which results in sensitisation of the reticulo-endothelial system. Later contact of the antigen and cell fixed antibody produces an abnormal reaction *within the cell, leading to the characteristic changes of rheumatic* fever

A very frequent clinical finding in cases of rheumatic fever is a history of a previous upper respiratory infection occurring one to several weeks prior to the onset This "lag period" though showing a wide scatter is usually 10–21 days, and it is during this time that it is decided whether rheumatic fever shall appear. If information as to this point is available it will practically invariably be found that the preceding infection resulted from hæmolytic streptococci. The "lag period" is of great interest as it is just the period of time *that* is required by certain other antigens to produce clinical sensitivity. The evidence for an allergic *factor in the production of rheumatic* fever has been summarised by Levinthal (1939). An increased *sensitivity of rheumatic fever patients to* the endotoxin rather than to the exotoxin of hæmolytic streptococci has been shown by Green (1942) This worker found that 200 cases of rheumatic fever and 200 control cases showed respectively 24·8 per cent. and 29 4 per cent. of reactors to exotoxin The rheumatic groups showed 71·4 per cent. of reactors to endotoxin compared with 23·3 per cent of *the control* groups

Geographical *localisation of this disease is broadly correlated* with the streptococcal carrier rate Swift (1942) has shown in institutional *cases that recurrences of rheumatic* fever are uncommon when throat

swabs are free from hæmolytic streptococci, but become common when this organism is present. Serological investigations are not convincing, but papers have appeared suggesting that the immune response is slow not only in the O antistreptolysins and antifibrinolysins but more particularly in the type specific anti-M precipitins (Swift 1944).

The United States Forces on war mobilisation experienced an unprecedented wave of streptococcal infections and, concurrently with this, rheumatic fever became a most serious form of wastage. Evidence, cited in the next chapter, showed that if the streptococcal infection rate was substantially reduced by sulphonamide prophylaxis the rheumatic-fever rate fell *pari passu*. Additionally, if quiescent cases of rheumatic fever were given [illegible] ith [illegible]

[illegible] de

[illegible] of strains were submitted to Griffith's typing. No particular strain or strains was shown to be associated with rheumatic fever, the predominant strains found from such cases varied in different parts of the country, as did the prevailing types of streptococci. Successful as were the workers in the United States in collecting information correlating streptococcal infection with rheumatic fever, their inquiries traced one fact that revealed the incompleteness of this ætiological standpoint. Camps in the north revealed a strikingly increased incidence of rheumatic fever over camps in the south. All camps were composed of men selected at random from all parts of the country, so that susceptibles in each camp would have been approximately equal in number. The food and environmental conditions were approximately similar. Streptococcal illness showed much the same type of incidence, and the predominant types (17, 19 and 30) were found equally in the north and south camps. Some factor as yet not traced was at work; this unknown factor [illegible] t the moment m[illegible]

It appears [illegible] are necessary f[illegible] production of rheumatic fever:

(1) An infection of the upper respiratory tract with hæmolytic streptococci.
(2) A susceptible hereditary background.
(3) Meteorology in some instances.
(4) An x factor.

Though [illegible] cocci [illegible] than [illegible] ultim[illegible] to be capable of initiating the rheumatic process.

Pathology of Rheumatic Fever

The modern view of this condition envisages widespread changes involving clinically or subclinically numerous bodily structures; many

of these changes are reversible, and discernible only by searching examination at post-mortem Two main lesions dominate the scene, firstly the Aschoff body and secondly vascular lesions The Aschoff nodule is derived from a focus of fibrinoid degeneration of connective tissue which later undergoes necrosis The histology of this body *depends largely upon the time during which it has been present.* In the fully developed nodule there are four main zones.

(1) The centre is composed of a small amount of necrotic material
(2) Around the centre are found the Aschoff cells, large, with one or several nuclei, with a cytoplasm showing ragged edges The cells, often scanty, and not always seen in the early stages, constitute the characteristic cytological feature of the lesion The origin of the Aschoff cell is disputed, but it is probably from the reticulo-endothelial system
(3) The third zone contains lymphocytes and plasma cells, on occasion polymorphonuclear cells occur
(4) A variable degree of fibroblastic reaction is present at the periphery of the lesion

The vascular changes are in the nature of a panarteritis The affected vessel is thickened and is surrounded by a cellular matrix containing polymorphonuclear and endothelial cells. The vessel endothelium is swollen and separated from the wall by fibrin The serous membranes, in particular the synovial membranes, show areas [illegible]

seen *whilst other areas may merely show areas of necrosis* [illegible] microscopic changes are completely insufficient to explain the cardiac failure and pathological methods are not adequate to show the degree of myocardial damage The valves are congested and œdematous, with rheumatic vegetations attached a few millimetres away from their free borders at the line of apposition. Microscopy reveals rather atypical Aschoff bodies, later secondary fibrosis may result with the formation of an incompetent or stenotic valve.

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CHAPTER XI

THE DIAGNOSIS AND TREATMENT OF RHEUMATIC FEVER

CLINICALLY the effects of rheumatic fever may be manifest in four ways, firstly as a general illness, secondly as an articular complaint, thirdly as a cardiac disease, *and fourthly, but* rarely, with symptoms and signs suggestive of disease in other systems

The symptoms of the general illness *are in no way specific and* alone are insufficient, except in a case with a definite history of old rheumatic fever, to establish a diagnosis. Signs and symptoms related to systems other than the heart or joints, *i.e. pleurisy, are of* little help in diagnosis and may prove extremely misleading

The articular manifestations usually exhibit a fairly striking clinical picture, but unfortunately except from *a symptomatic view*-point are of little importance as compared with the often insidious, asymptomatic and frequently lethal cardiac lesions Thus from a diagnostic angle a vitally important type of heart disease may depend for its diagnosis upon an inconstant pattern of articular signs and symptoms

That the situation is unfortunate, to say the least, is revealed by assessment of cases of fully developed rheumatic heart disease Rheumatic heart disease has been shown by histological methods to be the cause of mitral stenosis in 95 per cent. of cases, and yet if a series of these patients is questioned only about 30 per cent. will give a history of unmistakable rheumatic fever, a further 20 per cent of probable rheumatic fever, and perhaps another 10 per cent. a history of chorea, these figures show considerable variation in the practice of different cardiologists, but it must be remembered that they are compiled in retrospect, when the diagnosis is obvious, and will be unconsciously biased in a positive direction. The conclusion is inescapable that in many cases the initial and sometimes the subsequent attack of rheumatic fever escapes diagnosis, either because medical attention is not thought necessary, or because the attack does not correspond to any well-defined clinical picture.

A further serious flaw in our knowledge of this complaint is its incidence not only as a clinical state, but as a subclinical illness. A recent paper by Hall and Anderson (1943) is pertinent to this inquiry These workers examined 112 hearts without clinical evidence of rheumatic heart disease, or other gross lesion, and claimed to demonstrate macroscopic and microscopic evidence of rheumatic lesions of the mitral valve or its vicinity in two-thirds of cases *Karsner (quoted by Parkinson, 1945) apparently arrived* at similar conclusions though in a smaller proportion of cases. Hall and Anderson write· "Just as the pleural scars at the apices of the lungs

are the 'vaccination marks' which indicate immunity to tuberculosis, so the minimal valvular lesions, and microscopic hyperergic changes in the heart mostly indicate immunity to rheumatic fever resulting from previous subclinical infections "

This suggestion that the greater part of the population is comparatively immune yet has suffered a minimal infection, in line with the well-known sequence of events in human tuberculosis, appears to be extremely valuable

Confirmation of this work on a large scale would help to explain the greatest stumbling block in the acceptation of the theory of an intimate relationship between infection with hæmolytic streptococci and rheumatic fever The conception that rheumatic fever is only an expression of a quantitative difference in reaction to hæmolytic streptococcal infection rather than a qualitative difference to this stimulus obviously removes many difficulties Similarly such a conception helps to explain the remarkably varied clinical picture, and in particular the fully developed case of rheumatic heart disease with no history of illness

That the diagnostic net should not be flung too wide is indicated by several follow-up investigations of children complaining of "growing pains"—Hawksley (1938) Shapiro (1938), Hubble (1943) These authors showed that only a minute proportion of children complaining of this type of pain developed rheumatic heart disease

The age incidence of rheumatic fever is of some help in diagnosis Very rare before the age of three, it reaches its maximum incidence at the ages of eight to twelve and then declines Nowadays adult rheumatic fever is relatively more common than formerly

Clinical Picture

As has been previously mentioned the diagnosis except in "classical" cases may be a matter of considerable difficulty There is no one pathognomonic sign or laboratory test

The onset usually occurs from a few days to some three weeks following a sore throat This feature may be absent The onset may be acute or insidious Usually there is pain or stiffness in one or several joints, a moderate pyrexia associated with a tachycardia not accounted for by the height of the fever, accompanied by excessive perspiration, which is stated by some clinicians to have a characteristic odour

The affected joints are usually those of the knees, ankles, shoulders and wrists, but the hips, elbows and small joints of the hands and feet are not infrequently involved The affected joint is hot, swollen, red and tender, and movement causes considerable pain, the subjective signs, especially the tenderness, are usually considerably more prominent than the objective signs The polyarthritis is characteristically migatory, the affected joint becoming clinically normal in two to ten days Not infrequently, in the untreated case, a joint which has become normal may exhibit one or more recrudescences In the average case several joints are affected at the same time, and the process is not limited to any particular pattern of joints or to

any particular joint Atypical articular involvement occurs not infrequently, and in some cases the resemblance to rheumatoid arthritis may be considerable, prolonged observations will usually solve a difficulty of this nature

The fever may be high (usual range 100°–104° F.), it is irregular and atypical, responding with considerable rapidity to salicylates. The older clinicians described frequent drenching sweats, but these do not appear to form so frequent a component of the clinical picture as formerly.

Tachycardia is invariable, and even when the temperature responds to salicylates, the tachycardia tends to remain unabated Loss of weight appears in a number of the more severely ill patients and may be marked especially in children Epistaxis occurs in some cases, and sometimes marked pallor occurs in the course of the illness Complaints of general debility, fatigue and anorexia are common. The question of pulmonary lesions in rheumatic fever has been the cause of much controversy, as in the rare cases where post-mortem evidence is obtained the histology is difficult to interpret. Rheumatic pleurisy appears to be a definite entity (Paul, 1928); it is usually dry in type, but in fatal cases, probably due to concomitant heart failure, it is frequently wet

Hadfield (1938) has described what he regards as a characteristic lesion of massive pulmonary consolidation occurring during the stage of carditis—these lesions appear at least in the earlier stages to be transient (Coburn, 1931). Some excellent microphotographs of the lesions with a discussion of the ætiology are given by Rich and Gregory (1943).

Two further manifestations remain for consideration, nodules and skin lesions The incidence of these varies remarkably in published series The skin lesions are treated in a separate chapter and it suffices to say that they include erythema nodosum, erythema

as the true rheumatic eruption The lesions are believed to be related to increased capillary permeability. The subject has been reviewed by Keil (1938).

Rheumatic nodules are lesions of considerable importance, unfortunately their tendency to occur only in the more seriously ill cases reduces their value in diagnosis. Usually varying in size from ... carefully

...gers,

...usly,

being attached to joint capsules, tendon sheaths, or ... eum In general they are sparse but occasionally up to one hundred may be present at one time, they disappear after a period of up to several weeks, but may return in crops or singly. They are seen also in rheumatoid arthritis, in which condition they are less evanescent. The histology is variable but usually they are composed of three layers: a central necrotic zone; a mid zone of stellate and spindle

cells, frequently arranged radially, and a zone of congestion, lymphatic infiltration and œdema Whether or not the nodules in rheumatic fever and rheumatoid arthritis are identical is still a matter for discussion Some authors regard the presence of nodules as being indicative of active disease, this would appear to be an uncertain assumption

The blood picture usually shows a leukocytosis up to 20,000, occasionally eosinophilia of low degree is present The sedimentation rate is markedly raised, but initially the red cells may show no abnormality Later in the illness the hæmoglobin and red cells may fall considerably, with either the production of a microcytic, a normocytic, or a microcytic hyprochromic anæmia—the latter picture is much the most frequent, in a severe case the fall may be as low as red blood cells 2,500,000 per c mm with a low colour index

Urine during the stages of severe infection, high fever, or congestive cardiac failure is likely to show moderate albuminuria During the stage of activity a few red cells are sometimes seen

Cardiac lesions—It is probable that no case of rheumatic fever escapes cardiac involvement, the old adage "Rheumatism licks the joints but bites the heart" is probably even truer than its author thought

Modern histological data indicates that, though the ultimate lesions of rheumatic fever may be apparently localised, the initial lesion is more correctly spoken of as a pancarditis The methods at our disposal for demonstrating cardiac involvement are crude, as physical signs are dependent upon the appearance of a significant degree of dilation and the electrocardiograph shows only conduction disturbances and the more advanced myocardial lesions Thus reliance on physical signs and electrocardiographic evidence is not sufficient to exclude carditis initially or later, and the management of a case requires that greater dependence be placed upon the more general features, such as the weight, blood examination, etc, than upon the absence of demonstrable cardiac signs

In the following description attention is paid only to features of the first attack or a subsequent attack in a clinically normal heart

Symptoms—Precordial pain is infrequent and not often severe. Palpitation sometimes occurs and is usually due to effort syndrome, sometimes it is related [illegible]
beats, dropped beats, c [illegible]
unless in the presence [illegible]

Dyspnœa may be compliained of and will suggest effort syndrome, pericarditis with effusion, or cardiac dilatation with failure

Signs are extremely variable In the minimal cases there may be nothing but a systolic murmur at the apex with perhaps demonstrable dilatation, in the most severely affected cases there may be great cardiac enlargement with several murmurs, arrhythmia and congestive failure

The usual findings are: first a soft systolic murmur at the apex with a diffuse apex beat and perhaps demonstrable increased cardiac

dullness, these, though very suspicious, are not, in the absence of joint phenomena, conclusive of carditis, as a soft systolic murmur is not uncommon in fever, and the apex beat is subject to variation in different patients. An apical diastolic murmur usually well localised and often preceded by a split second sound may appear, the systolic murmur having in the meanwhile become louder and harsher. A diastolic murmur may appear along the left border of the sternum together with a systolic murmur at the base The diastolic murmurs are of great value in diagnosis They do not indicate valvular damage at this stage, but dilatation of the heart, which at this point is *practically always demonstrable* by physical signs or X-ray. A [illegible] this

[illegible] *angle* examination. Frequent auscultation, measurement of the apex beat, and heart size will often enable a diagnosis of carditis to be confidently made in a case where at any isolated *examination the diagnosis could* only be ventured.

The electrocardiogram is often normal except for the sino-auricular tachycardia so frequently present. The most usual abnormality is found in a lengthening of the P R interval (over 0 2 sec.), but arryhthmia, abnormal T waves, or intraventricular block may be shown Recently Reyersbach and Kuttner (1940) have cast doubt as to the validity of regarding 0 2 sec as the upper limit of the P.R interval in children Electrocardiographic abnormalities are often transient, so that repeated examinations are necessary if the above changes are to be demonstrated.

TREATMENT OF RHEUMATIC FEVER

Previously the treatment of rheumatic heart disease was *symptomatic* except in the advent of cardiac failure, but recently two measures which may prove to be of real importance in the control of the disease have been described *The first is the prevention of recurrences* by sulphonamide medication, and the second is massive salicylate medication in the treatment of the disease

Treatment by rest is our sheet anchor in this disorder. That the patient must be put to bed, and kept there at absolute rest during the acute stage of the disorder, is accepted by all. It is usually taught that the flatter the patient lies in bed the better, as a concession to comfort one pillow is allowed It would appear that this position, designed to relieve the heart of as much work as possible, is [illegible] There is a considerable [illegible] e recum- [illegible] adstone, 1935, Donal, Gamble and Shaw, 1934, Sweeney and Mayerson, 1937) It would appear reas[illegible] and nurse the patients in the [illegible] usually sitting It is notewo[illegible] *it will probably become essential* to nurse these patients in the sitting position owing to orthopnea. To fix the optimum duration of bed

rest is often a matter requiring considerable nicety of judgment and is considered under "convalescence"

Care of joints is usually simple, as response to salicylate medication is in the majority of cases rapid

During the acute stage splintage by pillows, with a cradle to remove the weight of the bed clothes, is mostly adequate. In severe cases the superior immobilisation obtained by the use of a plaster shell may be required, and comfort is sometimes produced by the local application of methyl salicylate

SALICYLATE THERAPY

For many years controversy as to the value of salicylates in rheumatic fever has raged All admit that the salicylates are of great value in the treatment of the articular symptoms, but the effect, if any, on the disease process has been hotly argued

In recent years the belief has been growing that the use of salicylates is confined to symptomatic relief

Brodie, Undenfriend and Coburn (1944) have recently described a method for the determination of plasma salicylate, and Coburn (1943) has used this method for a study on the effects of salicylate medication during rheumatic fever

Coburn's paper deserves close study by all who have to care for patients suffering from acute rheumatic fever He examined the plasma level after varying salicylate dosage, and the effects of varying levels on the sedimentation rate and clinical condition of these patients

The patients were young adults and though the figures are

The observations suggest that a

gamma–0 001 mg) is sufficient to

f 350 gamma/c c suppresses the

rheumatic reaction These results show that none of 38 patients treated with doses of 10 gm or more, daily developed valvular heart disease, whilst 21 out of 63 similar cases who received smaller doses (6 gm daily) showed physical signs of heart disease The effects on sedimentation rate, duration of illness and clinical state of patients were striking Coburn advocates initial intravenous injection to obtain rapid build-up, as plasma peak levels were only revealed after 48 hours of oral dosage Intravenous administration also helps to circumvent nausea and vomiting

Coburn's provisional dose schedule (for young adults) is given below It appears that an adequate dosage is 0 13–0 19 gm /kilo body-weight

Day 1 10 gm. of sodium salicylate in 1,000 c c of 0 9 per cent sodium chloride administered by intravenous drip in 4–6 hours

Day 2 If the patient has any rheumatic symptoms or if the temperature has not reached normal 20 gm of sodium salicylate in 2,000 c c of 0·9 per cent sodium chloride is administered in 8 hours

Day 3 This can be repeated if necessary, but with the patient asymptomatic and afebrile 10 gm of sodium salicylate is adequate.

Day 4–6 Daily infusions are continued until the B S R. has made an appreciable drop—e.g about 20 per cent.

Day 7–30. Oral treatment replaces intravenous therapy. Doses of 1 6 gm. of sodium salicylate and 0·6 gm. sodium bicarbonate are administered every 4 hours day and night. A total of 10 gm. of sodium salicylate is given daily during this period.

Day 30 After two weeks or more in which the sedimentation rate remains within normal limits the *patient is allowed a trial week* of bed rest without salicylates. If he remains symptomless and maintains a normal B S R. for one week he is allowed up progressively. *If, however, that patient develops symptoms, fever, or a marked rise* of B S R another two weeks' course of therapy is given. This course is either begun with oral administration or one intravenous infusion *of 10 gm followed by oral doses as outlined above.*

It must be emphasised that Coburn's work has been on a relatively small scale and in adults Even if it is adequately confirmed it does not solve the problem of the rheumatic state, as he himself admits

The large doses recommended must be surveyed in the light of their possible toxicity. Coburn had one patient who showed signs of intolerance due to cerebral stimulation.

The lethal dose of sodium salicylate is not exactly known and is undoubtedly variable. Salicylate poisoning resembles cinchonism very closely. Headache, dizziness, ringing in the ears, difficulty in *hearing, dimness of vision, mental confusion, sweating, thirst, nausea* and vomiting, acceleration of the pulse and respiration may all be noted.

Symptoms of cerebral *excitation occur and with larger doses the* condition of "salicyl dyspnœa" is seen, but though the condition resembles diabetic acidosis neither the alkali reserve or pH of the *blood are materially altered, it is thought to be due to direct stimulation* of the respiratory centre. An additional danger was thought to be depression of the prothrombin level, but work by Butt *et al* (1945) has shown that this is not material with the doses used Happily the excretion of salicylates is rapid, and practically all reactions are readily reversible. Some salicylate deaths were, however, reported last year in America, and two controlled reports (Murphy, 1945, and Wegria *et al*, 1945) have been critical.

The more usual dosage is to give salicylates two or four hourly until either the symptoms are relieved or toxic effects occur, when the dosage is reduced Sodium salicylate is prescribed with equal amounts of sodium bicarbonate to reduce gastric irritation There is some evidence that dosage with salicylates after a sore throat may help to prevent an initial or recurrent attack of rheumatic fever.

Anæmia is seldom a serious problem. The frequent hypochromic anæmia usually responds to iron, sometimes only after the disease process has become quiescent In cases of severe anæmia small *multiple transfusions may* be required

Tonsils —Sometimes a patient with rheumatic fever is seen with an acute tonsillitis produced by hæmolytic streptococci. It seems

rational in such cases to eliminate this infection with sulphonamides, though these drugs cannot be advised in acute rheumatic fever.

If the tonsils show evidence of chronic infection they should be removed after the acute infection has subsided It must be remembered that the removal of tonsils is only advised on general grounds, as tonsillectomy is no guarantee against recurrence of the disease, though it may confer some advantage in this respect

Diet

A liquid or semi-solid diet may be given in the acute stages of the illness, but since this is a chronic disease the maintenance of optimum nutrition is extremely important As soon as the child's appetite allows, feeding should be generous, in an endeavour to increase the weight Some workers have endeavoured to incriminate lack of certain vitamins as a subsidiary cause of breakdown, the evidence for this conception is not strong, but nevertheless it is advisable to provide a diet of generous vitamin content

Heart failure is unusual in the first attack of rheumatic fever. When cardiac failure occurs it is nearly always total failure, i e failure of right and left sides of the heart simultaneously The signs and symptoms are chiefly those of venous congestion involving the systemic circulation rather than the pulmonary circulation

The usual methods of treatment restriction of fluid and salt intake, a low calorie diet, absolute rest and the use of diuretics will be employed

Considerable controversy surrounds the use of digitalis in failure due to acute rheumatic fever. That digitalis has less than its usual therapeutic effect under these conditions is admitted even by the exponents of its use Opponents of this view state that digitalis medication is merely applying a further toxic influence on a myocardium failing from toxemia Under these circumstances its use is

Convalescence

The management of convalescence is a matter of great difficulty in some cases, as the process may smoulder for a period of months or even years

The judgment of the activity of the rheumatic process has to be decided on imperfect criteria Additionally a number of children will be left with permanent cardiac damage and this will make the estimation of rheumatic activity more difficult.

The general condition of the child is of some help, a gain of weight is a valuable sign of quiescence

The interpretation of the pulse rate and temperature is often difficult Rheumatic fever may be an afebrile disease and a normal temperature is no surety that carditis is still not progressing Some

children have a normal temperature as low as 97° F. and others as high as 99° F This question must be decided *on the evidence of all* available temperature charts.

The pulse rate should be taken during sleep *as well as in the day-*time, and it is often the former reading that is the more valuable. An important point was mad[illegible]
an absolute rise in rate but
between the sleeping and al
the patient up, even with no other signs, if the sleeping pulse is over 100 (allowance for age must be made).

Chorea is a sign of activity, and many authors feel that the presence of nodules has the same significance.

Blood examination is of considerable value, a resistant hypochromic anæmia is probably a sign of activity, as is a leukocytosis. The sedimentation rate is of great value but should not be used as an absolute indication

Extension of physical signs in the heart will show activity, but, in view of the fact that a systolic murmur frequently persists after the first attack, too much reliance should not be placed on the presence of physical signs as indicating activity

A broad view must be taken of the case, as a number of the patients will be left with permanent disability that no amount of bed rest will cure, and in them the aim must be to make the best of what remains

When the child is allowed to get up, only gradual increase of exercise can be allowed, and this must be checked by the means already mentioned It is not possible to lay down definite rules, as each case must be considered on its merits

The question of schooling during such an illness should not be overlooked, as these patients will be dependent upon a sufficient degree of education to enable them to live a sheltered life. Convalescence is best spent in special institutions for this purpose, where educational facilities are provided

The Prognosis of Rheumatic Fever

The prognosis of rheumatic fever is of very great interest and importance

Coln and Ling (1943) have recently completed a valuable statistical study of 12,000 cases of this disease, 3,129 of whom had died. This work was done on cases under the auspices of the New York Heart Association, who provided standard forms and standard diagnostic terms These papers should be consulted in the original as it is not possible to make an adequate summary of the large amount of data collected and analysed

Briefly these workers found that the highest incidence was found at the age of 8, that 70 per cent of all cases had occurred by the age of 15 and that only 3 per cent of cases originated over 40 The figures for males and females showed considerable similarity

From the time of onset to a "follow-up" thirteen years later 75 per cent of the cases had one or more recurrences, 51 per cent had two

recurrences; 32 per cent had three recurrences, 20 per cent had four recurrences and 12 per cent had five or more recurrences By far the greatest number of recurrences occurred between the ages of 5–14, and the onset of puberty was shown to have a striking influence on both new cases and recurrences

In childhood carditis is the most frequent but rarely the only type of manifestation At all ages polyarthritis is the most frequent single manifestation.

The earlier the age at onset the greater is the chance that the disease will be "severe," and similarly the prognosis is far less favourable with "mild" signs of infection in childhood than with the same signs in older persons

When the infection is "severe" in the early years of the disease, expectancy is shorter than when the disease is "mild" Of children with "severe" infection, less than one-half survive childhood, about one-tenth survive adolescence, and less than 2 per cent the third decade Even when the infection is mild, only one-third survive to the age of thirty and only one-tenth to the age of forty-five

When the first manifestation is carditis the chances that the subsequent course will be severe are 3 to 1, but if joint pains, chorea, or a cardiac murmur only are present, the chances are 3 to 2 that the subsequent course will be mild In adult life subsequent recurrences are mild or absent in 9 out of 10 cases

Of the fatal cases the average period of survival from the onset of the infection was 13 years, but a less gloomy view may be taken as 25 per cent of cases lived 17 years or longer

Whilst these case facts are not new, Coln and Ling have performed a considerable service in placing them on a sound statistical basis It is possible that these figures, collected between 1870 to 1938 (58 per cent occurring after 1920), may paint too dismal a picture, as it is a widespread belief that the ravages of rheumatic fever are now less quantitatively and qualitatively than formerly

Sulphonamide Prophylaxis

There is strong evidence that rheumatic fever in its initial and recurrent attacks is related to infection with the hæmolytic streptococcus It was felt that if these infections could be prevented a corresponding reduction in rheumatic fever might result

Since the advent of sulphonamides several investigations to test this hypothesis have been made The potential dangers of long-continued sulphonamide medication are well known, but it was felt that the very serious risks of recurrent rheumatic fever might in practice counterbalance the hazards involved The problem involved is twofold In the first place, is the measure effective, and secondly,

in the United

tion provided

material for a large-scale trial of this measure Both the United States Army and Navy experienced a very high attack rate of streptococcal infection and rheumatic fever in their training corps

Coburn (1943) reported on the administration of 0 5 gm. or 1 gm of sulphadiazine daily to 250,000 naval trainees. The results of this well-controlled trial indicated that, by such medication, a reduction of 85 per cent. in streptococcal infections resulted, which was accompanied by a nearly parallel reduction in the rheumatic-fever rate The medication was continued *for periods up to four months, and* Coburn stated that the incidence of all types of reaction was 0 5 per cent Half of the reactors (skin manifestations) were able to continue *with the course after an interval. Only 0·01* per cent. of serious reactions (exfoliative dermatitis or agranulocytosis) occurred. There was one death and post-mortem appearances showed leukæmia. Holbrook (1943) reported in rather less detail a similar large-scale experiment in the U S.A Army His findings were largely similar to those of Coburn Holbrook studied 40,000 men with special regard to toxic reactions and stated that these amounted to 0 12 per cent only 0 03 per cent of patients required time off duty. There were no deaths

Neither author found that resistant bacterial strains were produced though great care was taken to test this point, and both reported that the response to therapeutic doses of sulphadiazine was unimpaired. The results suggested that toxic reactions were most likely to occur two to six weeks after starting therapy.

These studies show that the administration of 0 5 to 1 gm of sulphadiazine daily to fit men for periods up to four months is a procedure involving very little risk, and one, under the conditions of the experiment, *of great utility in reducing streptococcal and* rheumatic infection

Sulphanilamide has been used by several workers for periods up to four years in the prevention of rheumatic relapses. Barclay *and* King-Lewis (1945) have summarised the evidence. Their collected figures showed that sulphanilamide-treated patients experienced 6 relapses (1 2 per cent) in 501 patient-seasons, whilst the relapse rate for 505 patient-seasons in untreated controls was 19 8 per cent Thomas (1944) stated that prophylaxis carried out for 815 patient-seasons resulted in a relapse rate of under 1 per cent compared with 10–35 per cent. among untreated controls

Most observers reported that toxic reactions were minimal, but Stowell and Button (1941), the only workers who reported adversely, gave up prophylaxis largely owing to the difficulty of regular supervision *of the patients This resulted in one death from* agranulocytosis. The collected results indicated that the period of greatest danger from severe toxic reactions was between the second and sixth *weeks*

Children suffering from rheumatic fever run the risk of a recurrence rate of 50 per cent within three years at a conservative estimate, and *it would appear from the admittedly* incomplete data that the risk of [illegible] with perhaps subsequent early death, [illegible] risk of a serious toxic reaction from a [illegible]

The choice of compound is difficult Sulphanilamide, though it

has been used over longer periods than the others, is probably not the compound of choice, as its toxicity is almost certainly greater than sulphadiazine It is also relatively an inactive preparation, and its excretion is rapid. Sulphadiazine has been given a very extensive trial over short periods; it appears unlikely that any serious reactions not seen with sulphanilamide will develop over longer periods It is a highly active compound with low toxicity, and its excretion is much slower than with sulphanilamide resulting in higher and better-sustained blood levels From a theoretical viewpoint sulphamerazine would appear to have high claims As far as is known its toxicity is very low, its activity is approximately that of sulphadiazine, but its excretion is slow and leads to high and well-sustained blood levels on low intermittent dosage

The evidence indicates that children who have had an attack of rheumatic fever with carditis should receive 0 5 gm of sulphadiazine daily either throughout the winter or throughout the whole year Adults who have had rheumatic fever but who have had no demonstrable involvement of the heart are possibly not suitable for this therapy, but if carditis has been present they should receive 1 gm daily Wilson and Lubschez (1944) criticise the published results of sulphonamide prophylaxis on the ground that the controls have been picked unsuitably, and that the biostatistical data is unfavourably influenced. Uncritical acceptance of sulphonamide prophylaxis would certainly be unwise, but the published figures are on a very large scale.

[illegible] complete failure of [illegible] tre, owing to the [illegible] type 19) These authors showed that even the administration of 2 gm of sulphadiazine daily was of no prophylactic value in the presence of these resistant strains, also the usefulness of this drug in therapeutic dosage was seriously impaired This failure of prophylaxis does not mean that prophylactic medication should not be given to cases of rheumatic fever, as the failure occurred under conditions very favourable to the production of resistant strains, which conditions are not met with when employing individual prophylaxis The period for which the patient should receive sulphonamide prophylaxis is not known Cessation of the drug at any period places the patient at hazard In children it would appear essential to continue the drug at least to puberty if possible Further information as to the safety of this procedure is urgently required Medical supervision should be rigidly exercised throughout the period of administration, and twice weekly leucocyte counts should be performed in the period between the second and sixth weeks when the danger of serious toxic reaction is greatest

Since it now appears likely that before long a reasonable oral method of administering penicillin may be found it is possible, provided that economic objections can be overcome, that this drug may replace the sulphonamides in prophylaxis The important point at issue seems to be that prevention of hæmolytic streptococcal

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Recently Young *et al* (1945) have reported the complete failure of sulphadiazine prophylaxis in a large military centre, owing to the emergence of sulphadiazine-resistant strains (chiefly type 19) These authors showed that even the administration of 2 gm of sulphadiazine daily was of no prophylactic value in the presence of these resistant strains, also the usefulness of this drug in therapeutic dosage was seriously impaired This failure of prophylaxis does not mean that prophylactic medication should not be given to cases of rheumatic fever, as the failure occurred under conditions very favourable to the production of resistant strains, which conditions are not met with when employing individual prophylaxis The period for which the patient should receive sulphonamide prophylaxis is not known Cessation of the drug at any period places the patient at hazard In children it would appear essential to continue the drug at least to puberty if possible. Further information as to the safety of this procedure is urgently required Medical supervision should be rigidly exercised throughout the period of administration and twice weekly leucocyte counts should be performed in the period between the second and sixth weeks when the danger of serious toxic reaction is greatest

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infection has been shown to prevent a very great deal of recurrent rheumatic fever

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CHAPTER XII

CHOREA

Ætiology of Chorea

VERY much the same sort of argument is pursued in investigating

chorea

point of view there is undoubtedly a close relationship between the two diseases, and there seems little possible doubt that children suffering from chorea show a much greater liability to heart disease than those who have never had it In addition, it is no uncommon thing for a child with chorea to develop subsequently an attack of rheumatic fever

Pathology of Chorea

The histological picture of chorea does not satisfactorily explain the clinical findings No localisation of lesions is seen on post-mortem examination, though certain workers believe that some degree of striatal damage is common In view of the small amount of connective tissue present in the brain it is to be expected that the histology would not correspond to that produced by rheumatic fever in other parts of the body The condition is best described as a meningo-encephalitis Histologically, disseminated focal and perivascular lesions are seen with possibly some neuroglial reaction Small areas of degeneration and softening with structures resembling Aschoff bodies are described together with cerebral congestion Thrombosis sometimes occurs Usher and Jasper (1941) state that the electro encephalogram shows generalised abnormalities, dysrhythmias that are non-specific but common amongst the encephalopathies Decrease in alpha rhythms and the presence of a continuous slow-wave activity of increased amplitude is also seen

Clinical Features

Chorea occurs most frequently in the early autumn and in December in this country It is said to be the first and only sign of the rheumatic process in a quarter of the children who suffer from acute rheumatism The commonest age incidence is from five to eleven years Relapses are very uncommon over the age of twenty It is far more common in females than males Some people regard chorea simply as a symptom of rheumatic fever others think the two are separate entities There are usually some prodromal symptoms The child becomes easily upset and irritable is generally out-of-sorts and nervous and may suffer from enuresis The irregular inco-

ordinated grimacing movements then begin to appear and may be so severe that the child has difficulty in walking. The speech is sometimes affected, becoming hesitating with disordered articulation leading to clipped words, explosive utterances, or whispering. There is generally a past history of sore throats, odd erythematous rashes, or "growing pains."

General muscular weakness is often found, and the involuntary movements may interfere with respiration. Two particular signs are often present. When the hands are stretched out the wrists become flexed and the fingers hyperextended. This is sometimes called the "choreic hand." When the tongue is put out it is retracted with great rapidity. The abnormal movements may be much more marked on one side than the other, though it is very doubtful whether a pure hemichorea of rheumatic origin ever exists. The movements have to be distinguished from habit spasm. Schlesinger says that children with habit spasm always recognise what they do and will delight in its demonstration, whilst for the choreic child this is impossible as he has little knowledge of his movements. With habit spasm the same movement will be regularly repeated but in the choreic the movements are irregular and dissociated. In practice the choreic movements are fairly easy to recognise. The signs in the central nervous system vary from case to case and cannot be relied upon. Schlesinger has seen cases exactly like rheumatic chorea which proved to be tuberculous meningitis at autopsy. Encephalitis lethargica and cerebral tumour sometimes mimic chorea in the early stages. As in rheumatic fever, the condition of the heart is the first consideration. Cases of chorea nowadays seem to be more benign than they used to be, but the relationship of chorea and rheumatic fever is a fairly close one and the two are not infrequently seen in the same patient.

Treatment

It sometimes seems as if chorea is a syndrome with such a highly nervous element attached to it that perhaps more could be done if the type of child who is likely to succumb could be picked out, and have treatment before the disease showed itself. By treatment in such a case one naturally infers change of environment, and so on, rather than medicines. It seems that these children, many of them highly intelligent, suffer from an unstable nervous system and that this may result not only from psychological but from physical causes. Plenty of fresh air, especially at night, and sunlight during the day, coupled with a calm steady environment, should be useful in improving the [illegible]

from lack of fats, especially butter. [illegible] damp dark houses. It must [illegible]ne part in the [illegible]ints have been [illegible]r and rheuma[illegible]ched the peak

of the effect of predisposing causes in chorea. If this is so, then preventive treatment might reach its maximal effect in this disease.

So far as the cardiac complications are concerned exactly the same precautions must be observed in chorea as in rheumatic fever It is as well to remember that carditis is more likely in the first or second attacks, but several attacks may lead to mitral stenosis Nursing attention must be on a high and intelligent level and most nurses provide such attention, as these choreic children are particularly lovable Apart from absolute bed rest the question of "curtaining off" the patient nearly always arises This is a personal matter which every physician will decide for himself, being guided by his own personal pyschology

The question of *drugs* may be important

stand out Firstly, of those cases which react well to the drug there is no doubt in my mind that in some it has a definitely beneficial effect, which cannot be produced in any other way Within two to four weeks after a daily dose of 25 g a period of hyperpyrexia is experienced which lasts two to five days, and this is followed by a rash, which is usually of an erythematous type, occasionally causing alarm by being scarlatiniform or morbilliform in character This is often accompanied by a feeling of malaise and conjunctivitis An eosinophilia may be found at this stage If these symptoms have not appeared in two weeks further administration is dangerous After this Nirvanol "crisis" a most remarkable improvement occurs, and apparent complete recovery, at any rate so far as the general improvement and the movements are concerned may occur In cases when this favourable result occurs, relapses will also generally yield The use of Nirvanol has now been almost completely given up. It is believed that the undoubtedly beneficial effects that occur should be attributed to the pyrexia produced during the stage of toxic reaction Much safer and better-controlled methods of producing pyrexia are now available

Artificial Fever

The general trend recently has been to use *artificial fever* This is a form of treatment which comes up periodically in all diseases which tend to a long course and which are hard to influence by drugs The fever can be produced in a variety of ways, by intravenous injections of T A B vaccine or by various physical methods The whole difficulty is that, small degrees of fever (100°–101° F) produce no effect and high degrees (up to 105° F) are deplorably uncomfortable and, even, one might say, dangerous In addition to this, it is said that it has no influence on the incidence of carditis

Sedatives, chiefly the barbiturates, may be required Chloral is useful in the milder cases, but where the movements are causing exhaustion the barbiturates are more satisfactory, in very severe cases they must be given in adequate dosage to produce rest In view

of the possible effects of sodium salicylate in modifying the rheumatic reaction (see Rheumatic Fever) this drug should be given in high dosage.

Convalescence must be gradual If home conditions are good the child may resume schooling three to six months after discharge from hospital. Where home conditions are poor it is probably best for the child to start school earlier, attending for only half-time.

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CHAPTER XIII

THE RELATIONSHIP OF RHEUMATIC FEVER AND RHEUMATOID ARTHRITIS

SINCE the days of Ballonius (1642) rheumatic fever and rheuma- [illegible] tradit [illegible] declared his belief that some cases of rheumatoid arthritis originated in an attack of rheumatic fever that the idea of the two diseases belonging to the same 'family" came to be taken up Bitter opposition and even ridicule followed and Dyce Duckworth (1880) was one of the leaders of this school The unitary theory fell into disrepute but was later revived by Poynton

There can be no question that at first sight there seems little in common between a typical case of rheumatic fever in a child, with its slowly developing carditis, and the classical picture of infective arthritis in an adult with its maximum incidence in joints, and so it would seem almost unreasonable to put forward the thesis that the difference is more apparent than real Nevertheless there is good evidence of a link between the two conditions

A diagnosis of rheumatic fever would be generally agreed in any patient who fell ill with pyrexia, an arthritis of the bigger joints and some evidence of cardiac involvement In the acute stage clinical evidence of carditis may be restricted to a mitral systolic murmur and, as is well known, this comes and goes, and may disappear altogether, only to return many years later as fully fledged valvular disease. It is said by many authorities that the electrocardiogram shows alterations in the P R interval

This systolic murmur, on which the diagnosis may be said to depend, occurs in only about half the cases of rheumatic fever and, as stated already is not continuously present Tachycardia and a systolic bruit may be present in any infectious disease, so that cardiac involvement cannot be assessed at all in half the cases, and only sometimes in the other half Although electrocardiographic tracings should be taken in every doubtful case, many cases of rheumatic fever at this stage will be found to show normal curves It is said that serial electrocardiograms may show variations In the remainder of the cases the yardstick of cardiac involvement cannot be applied for lack of evidence The position would be clearer if evidence of cardiac involvement clinched the diagnosis of rheumatic fever, but recent evidence seems to indicate that the heart may be affected in rheumatoid arthritis.

In 1938 William Goldie found evidence that this might be so, and in 1944 Young and Schwedel made autopsies on 38 cases of rheumatoid arthritis They found cardiac lesions in 33 cases and in 25 of these

the lesion was rheumatic in origin The mitral valve was affected in 6, the aortic in 3 Both were affected in 9 cases The mitral, aortic and tricuspid were all affected in 5, and all four valves in 2 Congestive heart failure was present in 22 cases, the pericardium was involved in 10 cases Of the 38 cases, full *clinical notes were available* in 32, and in 14 of these the cardiac lesion *had not been detected clinically*

Baggenstoss and Rosenberg (1941) found 14 cases of rheumatic cardiac lesions in 25 post-mortem examinations on cases of rheumatoid arthritis A high proportion showed evidence of pericardial involvement Only 7 of the 14 had been known to have heart *disease* during life Bayles (1943) found evidence of rheumatic heart disease in 5 out of 22 necropsies

In the three series (all post-mortem studies) rheumatic heart disease was present in 65 per cent, 56 per cent., and 22 per cent respectively

Baggenstoss and Rosenberg report that the incidence of rheumatic *heart lesions in the whole of the post mortem material available at* the Mayo Clinic is 5 per cent Further, of 46 cases of rheumatic carditis found post-mortem only 21 had been diagnosed during life, i e 45 per cent. If this observation can be applied to cases as a whole it would mean that more than half the cases of rheumatoid arthritis have cardiac lesions which are silent. There may be certain traps in so applying it, as the incidence is high, and one or two of these cases may have died of acute rheumatism, although in Young and Schwedel's series Aschoff bodies were found only once. This might be accounted for by the age of the patients

It is always said that the bigger joints are involved in rheumatic fever, yet cases with involvement of the small finger joints are seen occasionally, and rheumatoid arthritis may often start in the knee joint or even in the hip joint

Pericarditis is a more common feature in rheumatic fever, but it occurs in connection with rheumatoid arthritis (and in the illustrative case notes which follow is included a case which demonstrates this—Case II)

Case I

S H Male Age 20 Soldier

This man was passed fit into the Army in January 1940, but gave a [illegible]

On 11 2 41 he was admitted to hospital again, and said that [illegible]

[illegible]

respiration 20 The heart was [illegible] due to extrasystoles *Blood pressure was 104/68 The electrocardiogram* showed left ventricular preponderance and ventricular extrasystoles

Two weeks later he developed swelling in the wrists

At this time the W B C count was 8,400, with 54 per cent. lymphocytes

In a month's time the heart was apparently normal again, except for a systolic murmur The knees and ankles were normal, but the wrists were still swollen and painful The blood sedimentation rate, originally 98 mm at the hour, fell to 48 mm at this stage

The man stayed in hospital for six months At the end of that time the sedimentation rate, which had fallen to 9 mm , rose to 16 mm The wrists and hands were deformed, swollen and painful, and he thought the pain was coming in the feet He was lost sight of on discharge

This case illustrates how very alike rheumatic fever and rheumatoid arthritis may be

Case II

F C Female Age 27 Shorthand Typist

Came to hospital in October 1940, complaining of pain and swelling of the small joints of both hands The wrists and elbows were also affected She said she had always been well, but her brother had suffered from rheumatic fever

On examination, there was swelling of the wrists as well as of the hands She was pale and inclined to sweat easily There was a systolic murmur at the apex, but no enlargement of the heart Blood pressure was 118/76 There was no enlargement of the liver or spleen

The sedimentation rate was 48 mm at the hour, and the white cell count was 8,000 with a relative lymphocytosis X-rays showed early change of an infective type in the wrists and hands

She was admitted to hospital for treatment, but at the end of the first week she developed a right-sided effusion which, on aspiration, showed a small number of polymorphonuclear cells, but was sterile on culture At this time the temperature began to swing between 101 2° and 99° F

A few days later she developed a pericardial rub and became seriously ill The W B C count rose to 14,000, and the sedimentation was 60 mm

With small fluctuations she remained in this condition for a month, when the heart began to settle down The X-ray had previously shown great enlargement, which was confirmed clinically, but now the apex beat began to come in The lung base also began to resolve, and at the end of September 1941 (ten months after admission) she left hospital The W B C count was 8,000 and the sedimentation 22 mm The systolic murmur was still present, and she still looked pale and ill, with a hæmoglobin of 80

I saw her twice more but she never recovered completely, and the hands and wrists became more and more deformed Eventually she died of congestive heart failure in December 1941

No post mortem was obtained

This case is quoted because it illustrates the fact that cases which can reasonably be regarded as rheumatoid arthritis may develop complications usually considered to be those of rheumatic fever.

Case III

F W Female Age 48 Housewife

Came to London in January 1942, complaining of pain and swelling in the hands and knees Has had pains in various parts of the body, but no

the lesion was rheumatic in origin The mitral valve was affected in 6, the aortic in 3 Both were affected in 9 cases. The mitral, aortic and tricuspid were all affected in 5, and all four valves in 2 Congestive heart failure was present in 22 cases, the pericardium was involved in 10 cases. Of the 38 cases, full clinical notes were available in 32, and in 14 of these the cardiac lesion *had not been detected clinically*

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respiration 20 The heart was enlarged and [illegible] due to extrasystoles Blood pressure was 104/68 The electrocardiogram showed left ventricular preponderance and ventricular extrasystoles

Two weeks later he developed swelling in the wrists

medicine by their forthrightness As the point certainly needs more evidence on ætiology, it would be well not to interfere with the natural development of things by too keen an advocacy

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joints There was marked muscle-wasting The right shoulder showed an effusion

The sedimentation rate was 55 mm at one hour, and the blood uric acid was 2 8 m grm per 100 c c The W B C count was 12,400, with 65 per cent. of polymorphs

She was treated with glucose and insulin, and her weight rose from 7 st 8 lb to 8 st 6 lb, when the treatment was discontinued After this, gold treatment was instituted, and the condition gradually became quiescent

She is still under treatment and at no time has the temperature or pulse rate been raised The joints are resuming their normal functions, but muscle-wasting and deformity remain

This case illustrates how unlike rheumatic fever rheumatoid arthritis may be, and how difficult it becomes, on occasion, to think they have a common ætiology

It is generally said that the arthritis of rheumatic fever is of a fleeting nature, "flitting from joint to joint," each joint resolving as the process passes on, and it is really astonishing how quickly a red swollen exquisitely painful joint may clear up General opinion would be that a case is not one of rheumatic fever if the joints fail to clear up, yet the first hint that the case is one of rheumatoid arthritis is the failure of the joints to resolve, and this may even occur as a r ... up

... oth conditions

I ... een extensively studied, opinion is divided as to their identity.

Prodomal symptoms, such as a sore throat, are more common in rheumatic fever but some cases of rheumatoid arthritis start with a streptococcal throat infection Response to salicylates has always been looked upon as a characteristic of rheumatic fever, yet not all cases respond, and some cases of rheumatoid arthritis are markedly influenced by this method of treatment

Pleurisy is said to have a high incidence in rheumatic fever, and some authors say it occurs in 44 per cent of rheumatic children, but McEwen was not able to find the typical cells of the rheumatic granulomata in pleura pericardium, or synovia Case II illustrates that pleurisy may ... less uncommon compl... the two condition... humid temperate climates and uncommon in tropical and subtropical zones, and both apparently have their maximum incidence in Great B...

found The unitary theory is perhaps in the ascendant, ... to remember that the opponents of this theory did a disservice to

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CHAPTER XIV

THE ÆTIOLOGY OF RHEUMATOID ARTHRITIS

AS the cause of the syndrome is unknown, a great amount of work has been done, and no doubt will continue to be done, on its ætiology.

The question of focal infection has been discussed in another chapter This leaves a variety of possibilities.

Two will be picked out for detailed discussion, the question of *bacterial* infection, either direct or indirect, and the possibility of the syndrome being due to a virus infection It is as well to remember that the *predisposing* causes seem likely to play some part, and that the reaction of the host may prove to be a crucial factor.

The Rôle of Infection

The evidence of *direct* infection is uncertain and incomplete From the clinical point of view the general picture is that of an infection, in a proportion of cases the onset is acute or sub-acute Pyrexia, tachycardia, sweating, malaise, and the general features of an infection are often found There may be a leucocytosis of a *moderate character, a raised blood sedimentation rate, and a shift to* the left in the Arneth count In considering the relationship of rheumatic fever and rheumatoid arthritis this aspect of the matter has been considered. These features, although generally regarded as clinical evidence of infection, may be met with in such metabolic diseases as diabetes and uræmia (Davidson and Goldie, 1936) It is only because such metabolic disturbances are not met with in infective

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They found positive blood cultures of an attenuated hæmolytic streptococcus from 16 5 per cent of cases of infective arthritis Joint cultures were also positive As may be readily understood, this piece *of work, conducted by competent observers,* and with such a large proportion of positive findings, aroused great interest and hope Failure consistently to repeat these findings has been disappointing A number of workers hold the view that secondary organisms of no importance were found. Gray, Fendrick and Gowen (1932), however, confirmed the previous findings

McEwen, Alexander and Buhim (quoted by Poynton and Schlesinger) found positive blood cultures in 10–20 per cent. of patients with rheumatoid or osteoarthritis, mostly streptococcus viridans Similar results were found in gonococcal cases and in non-rheumatic cases with tonsillitis. This renders the value of a positive blood culture in cases of arthritis problematical In the same

way, joints and lymph glands have occasionally given positive results

Schlesinger and Signy have recently found a number of Gram-positive diplococci in the joint fluids of cases of Still's Disease They were unable to culture these diplococci

Perhaps the evidence for direct infection may be summarised best by saying that clinical evidence in some cases favours it and that some workers have been able to substantiate the claim Against it is the fact that few workers have been able to agree and that the vast majority of the cases do not conform to what would be expected From personal experience one case of infective arthritis has provided positive blood cultures, in that case a hæmolytic streptococcus In one other case chronic infective changes in the joints had been present for several years, when the patient rather suddenly became seriously ill, with a swinging temperature (from 100°–104°) In this case a hæmolytic streptococcus was grown from the blood but it seems difficult to say whether this was a case of streptococcal septicæmia (with an unknown focus) grafted on to a rheumatoid arthritis, or whether it was truly part and parcel of the original disease The patient unfortunately died, but a post-mortem was not obtained This type of evidence, tempting as it is, seems equivocal but it is probably the sort of evidence which lies behind some of the opinion on rheumatoid arthritis

Indirect Bacteriological Evidence

Much of the more convincing evidence of infection comes from the work done on the serology of the disease Many workers have been able to show that antibodies exist in the blood stream to a higher titre than in controls

Indirect Evidence of Bacterial Infection

R L Cecil *et al* (1931) found streptococcal agglutions in the blood but only in a proportion of cases In a large series of cases of rheumatoid arthritis 97 showed agglutination with the typical strain of streptococcus at a dilution of 1 : 640 or higher, while 50 controls failed to give any strong agglutination Hæmolytic streptococci from other sources (scarlet fever or erysipelas) were also often agglutinable with arthritic serum Sera from cases of arthritis frequently gave a positive precipitin reaction with the protein fraction of *S hæmolyticus* Various authors have found antistreptolysins and antifibrinolysins in varying proportions E W Todd (1932) developed a method of judging the antistreptococcus lysin titre, and this method has been used and approved by many authorities A streptolysin is prepared by growing certain streptococcal strains in a highly buffered broth medium, and is stored after filtration A 5 per cent saline suspension of rabbit's red corpuscles is used as an indicator of hæmolysis, and a minimal hæmolytic dose is ascertained After immunising horses with the antigen a standard antistreptolysin is prepared The antistreptolysin of the patient's serum is titrated and the titre is

taken as the reciprocal volume of the patient's serum which is required to neutralise one unit of the antigen after this has been standardised The titre has been found raised in various streptococcal diseases, particularly scarlet fever, erysipelas, and puerperal and rheumatic fever This method was used by Goldie and Griffiths (1936) and Coburn and Pauli (1935). Koerhner and Poulton (1938) studied 40 cases of rheumatoid arthritis, in all except nine the A S.L. titre was raised above 120, which they regarded as the upper limit of normal Antistreptolysins are only rarely found in normals or in osteoarthritis; antibodies are not found to be increased in joint fluids, and hæmolytic streptococci are very rarely found in joints, but have been so found by 3 sets of workers in 20 years. This may be because the disease becomes chronic, and the organisms die out, but some authors doubt that chronic arthritis is caused by a streptococcus or by any organism recovered from a joint fluid in rheumatoid arthritis.

A theory of "specific affinity" has been propounded, and it has been pointed out that certain bacteria produce certain diseases, e g the typhoid bacillus attacks the lymphoid tissue of the lower ileum, the meningococcus involves the meninges, and so on, but this is only partly true, though it may be looked upon as a "selective" action It is said that agglutinins to hæmolytic streptococci have been found in 70 per cent of rheumatoid cases, but there is no evidence of correlation between the titre found and the sedimentation rate or the clinical condition

A great deal of work has been done in the production of arthritis in *experimental animals* Streptococci isolated from cases of arthritis are injected into rabbits and, especially if the injection is intravenous, they develop the disease, and sometimes in a rapidly progressive form like the human form In this experimental arthritis the organism can often be recovered from the joints and the blood stream, and the serum shows high agglutinin content, sometimes said to be specific On the other hand, rabbits will show forms of arthritis without very great provocation

Those streptococci producing arthritis and those producing non-articular lesions are stated to have distinctive electrophoretic potentials, and it has been suggested that the pathogenic value of bacteria may be more easily determined in this way than by animal innoculation This work has not been confirmed. Recent work on hæmolytic streptococci by Green (1939), although most of it applies more directly to rheumatic fever, will be of interest. Evidence has been available for many years of the association of tonsillitis with acute rheumatism, and epidemic tonsillitis nearly always brings a crop of acute rheumatism in its train, though some of the cases may be c [illegible]

[illegible] with acute rheumatism (R)

a [illegible] Although the isolation of hæmolytic streptococci from the throats of the two groups was not significant, by means of the precipitin test the incidence of group infection in the rheumatic cases was 50 5 per cent and in the non-rheumatic 12·5 per cent This is statistically significant and on

investigations of this sort the infective theory of rheumatic fever has been built. Its application to rheumatoid arthritis may lie in the fact that cases starting with a sore throat are amongst the most severe we meet, and represent some portion of those which are originally diagnosed as rheumatic fever, fail to resolve their joints,

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that the streptococcal invasion may condition the organism for a virus infection The activation of a latent virus either by material of bacterial or non-bacterial origin is known as biotropism, and herpes febrilis is a good example, where the virus is harmless until some coccal disease (pneumonia) supervenes, when a crop of herpes presents itself Swine influenza is another example Schlesinger *et al* (1935) quote one of the modern views of cancer which postulates two factors, a carcinogenic agent and a virus (Cramer, 1938) Although subsequent agglutination tests gave some support to the virus view (Eagles, 1937) attempts to produce the disease in animals failed, but Mervyn Gordon found that when a hæmolytic streptococcus was mixed with a virus and injected into a rabbit the streptococcus disappeared, and thinks that this may be the reason why so many workers have felt it difficult to accept the streptococcus as a primary cause. The virus theory is thought by some to be unlikely because the rheumatic granuloma is not like a virus-induced lesion Rivers

tion of *acute* rheumatism and of rheumatoid arthritis, but the findings are indefinite The symbiosis of a virus with the streptococcus is

Allergy

A good many explanations which deal with the variation in

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immunity as well as anaphylaxis It does not require that "the altered capacity" shall be of an immunological order nor even that it should be an increased capacity Since then the meaning has been whittled down a good deal The tendency is now to remove the toxic idiopathies (such as asthma and hay fever), which perhaps should not have been included, into a separate class altogether (called by Aschoff "Anfalskrankheiten," or "attack diseases") and to keep the word "allergy" to indicate hypersensitiveness *only* to the toxins of bacteria in infective diseases The word "anaphylaxis" might be kept for

altered reaction to foreign substances. In this way, allergy is a helpful word to describe one of the effects of immunity, and quantitatively may vary in different conditions Rich (1933) investigated allergy and immune reactions by three methods. Firstly he produced acquired *immunity without the development of allergy*, secondly he injected the serum of allergic immune animals into normals and showed that the normal animals were desensitised and lastly shown to be immune but not allergic *Florence Seibert, using purified* tubercle protein, showed that animals immunised with this were hypersensitive to the protein of old tuberculin If these animals were injected with virulent bacilli they showed allergic phenomena but no immunity These experiments are the obverse of Rich's work, and tend to confirm it. *On this view allergy and immunity may be entirely separate qualities* Rich feels that, in this sense, allergy may be the means of converting harmless protein bacterial disintegration products into a lethal instrument

It should be useful to inquire whether a marked increase of reactivity to bacterial toxins is found in rheumatoid arthritis Zinsser thought that this was the case in rheumatic fever and quoted the sterile synovial fluids both in man and experimentally in animals, and said that this hypersensitivity ran *pari passu* with the general condition Others take the view that these are a part of a general immune reaction

If allergy was a feature, it would be expected that skin reactions to hæmolytic streptococci would help to demonstrate it. Certainly personal experience does not support this view. Dermal reactions seem to be unusually marked in some patients and not in others Sometimes they present themselves at once, but they may be delayed, and there seems no correlation between the type of case and the severity or time of the reaction Some workers found a positive skin reaction to hæmolytic streptococci in as high proportion as 90 per cent of cases (Wainwright, 1935), whereas only 10 per cent reacted to streptococcus viridans One author tested 78 cases of rheumatoid arthritis and 69 gave a positive skin reaction From this information he found the strain to which the patient was most skin-sensitive and used it as a guide to vaccine treatment He states that, by selecting his vaccine in this way, he produced improvement in 30 out of 45 cases of rheumatoid arthritis Green in the two groups of patients *R* (rheumatic) and NR (non-rheumatic) found 71·4 per cent of reactions to hæmolytic streptococcal endotoxin in group R and only 23 3 per cent in group NR *He tried to desensitise, and in large doses produced* reactions like erythema nodosum, and occasionally generalised reactions like a relapse of the rheumatism.

Recently Cooke has described two types of clinical allergy: in the first the symptoms occur within an hour of contact with the excitant —the immediate type, and in the second the symptoms occur much later—the delayed type The differences that he draws between the two groups are as follows The *immediate* type shows rapid onset of symptoms after exposure, a positive and rapidly developing skin and ophthalmic test which in general clearly indicates the excitant,

together with a suitable clinical history. In the serum of these patients it is possible to demonstrate the presence of skin-sensitising antibodies by passive transfer to normal skin, i.e. the Prausnitz-Kustner phenomena. He states that skin tests are of value *only in this type*, quoting two exceptions (*a*) positive skin tests not always indicating clinical sensitivity; (*b*) negative skin tests not always indicating absence of an immediate reaction, this is, of course, well known in particular the so-called non-antigenic substances such as aspirin and quinine

The *delayed* type differs from the above in several striking ways The reaction may begin several hours or several days after the exposure to the excitant, in such instances not only does the reaction always occur but it occurs after essentially the same incubation period frequent recurrences do not serve to materially alter this incubation period In such cases the skin test shown by the clinical test to be the excitant is negative, even when the reaction takes the form of an urticaria
further states that, wh
unknown the fact of its
only in its incubation period and perhaps in the rash, it differs, however, in having none of the serologic findings and no positive skin test at any time Obviously this type of reaction differs from the immediate type in its immunological mechanism This type of reaction is frequent with foods, drugs and bacterial substances, but very rare to air-borne excitants. In this group are placed many cases of urticaria and angioneurotic œdema, both external (cutaneous) and internal (abdominal and cerebral), of eczema and other dermatoses belong to this group, also all allergies of infective origin producing bronchial asthma, nasal and skin symptoms

The skin test for allergy should seek to reproduce the histological picture of the clinical allergy under study, for example one cannot and should i the cause of eczema, which is an means of the intra-dermal test itous immediate type of reaction Disregard for this fundamental principle has led to great confusion and error Probably the majority of people who have tried to use skin sensitivity as an aid to diagnosis or treatment would agree that it is a variable and uncertain factor This would apply both to sensitivity to bacterial toxins and to drugs One has only to think of such things as sensitivity to aspirin and the failure to show skin reactions to realise that the two things do not go hand in hand Landsteiner has given reasons why this may be On the other hand some physicians seem to derive satisfaction and success from this method and Cooke's work may alter opinion

Weintraud originally put forward the hypothesis that rheumatism was an anaphylactic" condition, and he was supported later by several experimental observers (Klinge, 1937) Leventhal (1939) puts the case in great detail, and makes the interesting point that an intracellular antigen-antibody reaction cannot occur unless the dose of antigen is too great to be neutralised by the circulating antibodies

It has been shown that after the injection of the original antigen the circulating antibodies gradually appear, but that at the time that hypersensitivity appears they have fallen considerably, and the tissue antibody has risen These two observ

He starts

1 That

esodermal localisation

2 That the initial histological reactions of the various diseases are in the main similar, though later developing different characteristics: this is a difficult point and probably cannot be answered on the facts as they are known at present. However, he mentions tuberculosis as an example of a single infection with remarkable protean manifestations, and this is of course true, and leads one to realise the striking differences that may be manifest in the microscopic picture without in actual fact indicating that a completely different type of reaction is occurring The differences are dictated not by the causative agent, but by the circumstances surrounding its introduction. Though in fact these reactions may be similar, the positive value of the evidence is small without further data

3 The rheumatic diseases are not local in nature but rather systemic This assumption in the sense that he uses it would be generally accepted

The conception that he maintains is briefly that the rheumatic disorders are not due to a specific micro-organism, but to a specific reaction of the macro-organism to an invasion by a foreign protein either living or dead, this conception requires that the tissues involved shall be hypersensitive to the antigen causing the stimulus The experimental evidence that he quotes in support is unexceptional and in accordance with current ideas Most people agree with the theory of cell-fixed antibodies, and with the theory of antigen-antibody reactions, but its application to all disease not only qualitatively but quantitatively must raise some doubt if all angles of this proposition are considered.

Later Levinthal says that "sensitisation is a legitimate part and stage in every immunisation" Now this statement is absolutely

here Rich's work on

ecomes important

Details are later

given of some experiments designed to show that the titres of a certain antistreptococcal precipitin were higher in the joints than in the sera of a certain number of rheumatic patients As far as they go these experiments appear to have succeeded in their aim; however scrutiny of the results reveals that there was no adequate control The correct control for these experiments would have included normal persons who possessed the precipitin in the sera but who *had no* joint disease, it would then have been necessary to show that these persons, despite their containing the precipitins in the sera, *did not* have excess precipitins in their joint fluid. This control would be difficult to furnish owing to the great difficulty of obtaining *normal* joint fluid

The theory of an allergic basis in a condition like rheumatoid arthritis is attractive if it is allowed that infection takes some part in its early stages Such a postulate may well be true and an antigen-antibody reaction may subsequently occur in the joints Recent work has suggested that this may be true and the effect of removal of foci of sepsis tends to support it It is evident to those familiar with the problem that such a theory is unlikely to be a complete answer.

The connection of arthritis with food allergy is even more unlikely, but has been suggested

Endocrine Factors

[illegible] art in [illegible] of it [illegible] case conflicting in character

The pituitary is now recognised as the gland which has a large share in controlling the endocrine team Until the function of the thyrotropic hormone is more fully understood there is no reliable evidence that the pituitary plays any part in rheumatoid arthritis Therapeutic trials with most of the available fractions of the anterior pituitary have yielded little benefit

The thyroid gland —At one time a good deal of work was done on the basal metabolic rate in rheumatoid arthritis, but most authors found normal figures and little interest has been shown for the last thirteen years In a series of twenty-five cases investigated in 1933 the results were all normal or near normal

The second line of inquiry has been into the association of thyrotoxicosis and arthritis At one time this was thought to be a significant association, but of recent years it has been realised how very common these two conditions are Some authors report improvement in the arthritis after a partial thyroidectomy but in a condition which has natural remissions it is difficult to be sure The late Mr Cecil Joll, a great authority on thyroid disease saw no significant connection However Poynton and Schlesinger quote Lantman as saying that *dysthyroidism* exists and he thought it had a common toxic origin with the arthritis Rheumatoid arthritis is seldom associated with myxœdema or a significantly low B M R though it is a slightly more common finding in connection with osteoarthritis The administration of thyroid extract in rheumatoid arthritis of even moderate severity seems to show a deplorable lack of clinical acumen but it must be recorded that improvement has been noted following its use.

The parathyroid glands —In 1928 Ssamarin advocated parathyroidectomy for rheumatoid arthritis Since then some work has been carried out on this problem and in 1940 Helfet stated that the inorganic blood phosphate level was controlled by the parathyroids Hyperparathyroidism withdraws calcium ions from the bones and he thought that the decalcification found in arthritis might be produced in this way So far as is known no consistent change in

It has been shown that after the injection of the original antigen the circulating antibodies gradually appear, but that at the time that hypersensitivity appears they have fallen considerably, and the tissue antibody has risen These two observations are in accord.

He starts with three assumptions.

1 That rheumatic diseases show a predominant mesodermal localisation This is reasonable

2 That the initial histological reactions of the various diseases are in the main similar, though later developing different characteristics: this is a difficult point and probably cannot be answered on the facts as they are known at present However, he mentions tuberculosis as an example of a single infection with remarkable protean manifestations, and this is of course true, and leads one to realise the striking differences that may be manifest in the microscopic picture without in actual fact indicating that a completely different type of reaction is occurring The differences are dictated not by the causative agent, but by the circumstances surrounding its introduction. Though in fact these reactions may be similar, the positive value of the evidence is small without further data

3. The rheumatic diseases are not local in nature but rather systemic This assumption in the sense that he uses it would be generally accepted

The conception that he maintains is briefly that the rheumatic disorders are not due to a specific micro-organism, but to a specific reaction of the macro-organism to an invasion by a foreign protein either living or dead, this conception requires that the tissues involved shall be hypersensitive to the antigen causing the stimulus The experimental evidence that he quotes in support is unexceptional and in accordance with current ideas [illegible] of cell-fixed antibodies, and w [illegible] reactions, but its application to [illegible] quantitatively must raise some doubt if all angles of this proposition are considered

Later Levinthal says that "sensitisation is a legitimate part and stage in every immunisation." Now this statement is absolutely [illegible] here Rich's work on [illegible] becomes important [illegible] t Details are later given of some experiments designed to show that the titres of a certain antistreptococcal precipitin were higher in the joints than in the sera of a certain number of rheumatic patients As far as they go these experiments appear to have succeeded in their aim; however scrutiny of the results reveals that there was no adequate control. The correct control for these experiments would have included normal persons who possessed the precipitin in the sera but who had no joint disease, it would then have been necessary to show that these persons, despite their containing the precipitins in the sera, did not have excess precipitins in their joint fluid. This control would be difficult to furnish owing to the great difficulty of obtaining normal joint fluid

The theory of an allergic basis in a condition like rheumatoid arthritis is attractive if it is allowed that infection takes some part in its early stages. Such a postulate may well be true and an antigen-antibody reaction may subsequently occur in the joints Recent work has suggested that this may be true, and the effect of removal of foci of sepsis tends to support it It is evident to those familiar with the problem that such a theory is unlikely to be a complete answer

The connection of arthritis with food allergy is even more unlikely, but has been suggested

Endocrine Factors

Most of the endocrine glands have been thought to play a part in the pathogenesis of rheumatoid arthritis The evidence some of it sound in its way is hardly ever of a direct nature and is in any case conflicting in character

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Later Levinthal says that "sensitisation is a legitimate part and stage in every immunisation" Now this statement is absolutely fundamental to his argument, this is of course where Rich's work on *the possible dissociation of immunity* and allergy becomes important. It is difficult to express an opinion on this point. Details are later given of some experiments designed *to show that the titres* of a certain antistreptococcal precipitin were higher in the joints than in the sera of a certain number of rheumatic patients. *As far as* they go these experiments appear to have succeeded in their aim; however scrutiny of the results reveals that there was no adequate control The correct control for these experiments would have included normal persons who possessed the precipitin in the sera but who had no joint disease, it would then have been necessary to show that these persons, despite their containing the precipitins in the sera, did not have excess precipitins in their joint fluid. This control would be difficult to furnish owing to the great difficulty of obtaining *normal* joint fluid

Protein metabolism was not found significantly altered, the fasting non-protein nitrogen, urea nitrogen, and blood uric acid were all normal Some workers have found a high blood uric acid, and this has been interpreted as due to renal failure. The value of uric acid findings in estimating renal function is a disputed point. Some think it is a very sensitive indicator, others feel it is not Possibly some of these cases were of gouty origin

Creatin was investigated both by blood levels and by creatin-feeding experiments It was agreed that high blood levels were common and the rate of excretion slow, and it was thought that this was due to the same mechanism that produces delayed sugar curves, interference with the blood flow in the finer vessels of the muscles. Creatinurea was an uncommon finding

lipoid metabolism appears to be normal Poynton and Schlesinger

by Pemberton and

the diet, especially

its quantity, was of importance in chronic arthritis, and found that a reduced food intake was followed by benefit Carbohydrate was most concerned, and they thought there might be difficulty in carbohydrate metabolism Giving 100 gm. by mouth, after the fasting level had been taken, they found there was delay in sugar removal, what we usually call a lowered sugar tolerance As the arthritis improved the curve tended to return to normal They found these features to be especially noticeable in those cases in which focal infection was a factor These findings were confirmed both in soldiers and civilians and have been repeated since by several other workers It seemed likely that this information could be used

one removal of some teeth with a focal infection led to a complete amelioration of the symptoms and a return to work This case was followed up in 1939 and was still symptom-free. As success with eradication of foci of sepsis had been obtained in only 2 per cent of cases of rheumatoid arthritis (see Focal Sepsis) this was rather encouraging, but the figures are far too small to be of any significance.

Sulphur Metabolism

First, to touch briefly on how sulphur occurs in the body, for it seems that the likelihood that sulphur may be of use as a therapeutic agent may best be as

It should be emp

(2–6) and a high and

as protein, and the fact that all proteins contain some sulphur is very

tissue in 28 per cent of the patients who had been operated on and had improved The few cases of parathyroidectomy recorded in this country have seldom been successful, and the operation should not be carried out for this condition

The sex glands—There is little clinical doubt that rheumatoid arthritis improves considerably during pregnancy and not infrequently patients become symptom-free, only to relapse into even greater misery after the baby is born Probably this first suggested the idea that the sex hormones were concerned in arthritis, but their administration seldom proves of benefit and Hench (1938) concluded that they were not responsible for the improvement in pregnancy. He thought that the lipæmia which occurs at this time might be a factor, and compared it with the lipæmia which is found in jaundice, a syndrome which is also said to relieve arthritis The rise in blood cholesterol was not thought to be a factor, although it appears both in pregnancy and jaundice, but differs substantially both qualitatively and quantitatively in the two conditions. In a personal series of 254 cases, rheumatoid arthritis started five times during pregnancy or immedi
chance.
was 9 7 fo
some relationship to the age incidence of the two conditions and no conclusion could be drawn from it

Suprarenal glands—Comroe reports that Watson (1940) found improvement in cases of arthritis following injections of cortin, and apparently overdosage with desoxycorticosterone acetate may produce polyarthritis in rats It was necessary to keep the animals in the cold to see this effect

Some of the other *ductless glands* have been discussed in connection with rheumatoid arthritis, and it has been said that diabetics suffer from arthritis very frequently Personal experience is against this, osteoarthritis or neuritis is an accompaniment but very seldom rheumatoid arthritis

Metabolic Factors

The occurrence of arthritis in gout, alkaptonuria, congenital hæmatoporphyrinuria and, it was said, thyrotoxicosis and myxœdema gave rise to the theory of a metabolic cause This was partly due to failure to separate the different forms of arthritis, and to distinguish between the mere association of two syndromes and their intrinsic re-

careful and detailed investigations he found the *basal metabolic rate* to be slightly reduced but thought this was secondary to the pathological changes found. No relationship has been found between the B M R and the activity of the disease

future It is possible that these facts are connected. Chondroitic acid itself sometimes fails to break down and appears in the urine, but no work is available which deals with its estimation in cases of arthritis

It is beginning to be thought that the cystine content of the nails is a guide to sulphur metabolism in the body Neligan (1934), in a study at Droitwich, found a low cystine content in 73 per cent. of his cases, and Loeper (1934) found a deficiency of sulphur in the cartilages and synovial fluid Race thinks that this may be due to a reduced albumin-globulin ratio in the plasma, as the cystine content of globulin is lower than that of albumin

Rawls *et al* (1935) treated 25 patients with injections of colloidal sulphur and found an increase in the cystine content of the nails in 21, with an average all-round increase of 2 58 mgm per cent per patient The sedimentation rate, although only slightly reduced, was considered significant from the statistical aspect, but there was no correlation between the sedimentation rate and the cystine content of the nails They concluded that the cystine content of the nails was lower in the older patients with rheumatoid and mixed arthritis and that sulphur

Race found deficient sulphur oxidation Todd (1937) concluded that electro negative colloids were drawn away from the blood stream by macrophages, and that this led to a stimulation of the reticulo-endothelial system Opinion is divided on the value of sulphur in the treatment of rheumatism.

Calcium

In view of the marked decalcification of bone which is an X-ray feature of rheumatoid arthritis, calcium metabolism should be of considerable interest

It has already been noted, however, that the present view is that calcium and phosphorus metabolism in arthritis is near-normal This is based on blood levels and confirmed by total balance tests It seems that this view must be accepted at present but some of the original workers found abnormal blood levels As is well known the technique of calcium balance experiments is very difficult, but the few carried out have proved within the limits of normality

Pemberton concludes that the *acid base balance* is normal in arthritis In view of the delicate mechanism available in the body for correcting this factor this would be expected

No evidence has been found to show that *lactic acid* metabolism is abnormal or incomplete Sweat has been found to contain a considerable quantity but no more in arthritis than in controls

Pemberton found that arthritic patients when first treated by rest in bed excreted more *water* than they ingested He found that soft-tissue swelling disappeared during this period and concluded that arthritis was associated with a low-grade œdema of the tissues which could be systemic in nature His experiments were carefully

often lost sight of. Proteins may contain anything from ·2 per cent (gelatin) to 5 per cent. (keratin) sulphur, and the amount of sulphur they contain has an important bearing on their metabolism and ultimate fate

The principal sulphur-containing amino-acids resulting from the breakdown of protein are *cystine and methionine (Barger and Coyne, 1928)*, and taurine, a constituent of the bile acids, which was isolated by Gmelin and has been known for one hundred years, is a derivative of cystine Cystine and methionine also yield glutathione (Hopkins, 1921) and insulin is a protein (Abel, 1926) which cannot do its work without its cystine content To show the complexity of this subject, the iodine titration method used for the estimation of glutathione *gives positive results for ascorbic acid. Cystine cannot be replaced* in a diet by elementary sulphur or inorganic sulphates but only by methionine, and in cases of cystinuria it is found that if the patient is fed with cystine he can oxidise it, so it is thought that methionine is at fault It has been shown quite clearly that sulphates can be formed from both cystine and methionine. Sulphur is an element which is all-pervading in the body and which enters into all natural *processes. Sulphur detoxicates poisons in the body both chemical* and bacterial. Sulphur is as characteristic of the epithelial cells of the skin as iron is of red blood cells or calcium of bones. Sulphur merely applied to the skin is changed to a form which permits it to reach the cystine-containing epidermal cells Indol (a product of tryptophane) has been shown by Forbes and Neale (1937) to be present in excess in the urine of patients suffering from rheumatoid arthritis, and to diminish with clinical improvement and disappear with recovery Indol normally breaks down to indoxyl and then combines with sulphur to form indican, which is potassium indoxyl sulphate Phenol, indoxyl and skatoxyl, and a great many aromatic alcohols, appear conjugated with H_2SO_4, or may pair with taurine, so that the presence of sulphur is necessary for their detoxication, and it may be that this is an important point in the value of sulphur therapy Carbohydrates may take the place of sulphur-containing proteins, and Fletcher (1939) produced an acute exacerbation in a case of arthritis with a very high carbohydrate diet. The use of sulphur is, therefore, very often combined with a low carbohydrate diet, and some good *results have been obtained, mostly* in America, with this combination, especially in cases of rheumatoid arthritis.

The organic matrix of the joint cartilages is composed of two proteins, and one is a simple protein united with chondroitic acid. Chondroitic acid when hydrolysed, breaks down into *chondroitin* ... becomes

blood, although this has been attributed to a reduction in the ... of the erythrocytes, as the plasma itself contains no glutathione A good deal has been made of this point, but it is not certain yet whether the onset of the arthritis and *the loss of the cartilage* sulphur go hand in hand, but more work will probably be done on this point in the

the United States On the other hand, dark adaptation curves are said to be abnormal

On present knowledge vitamin A deficiency in rheumatoid arthritis rests on a very slender basis.

Vitamin B Complex

This consists of the heat-labile component vitamin B_1 (antineuritic factor) and a number of *heat-stable* components, vitamin B_2

Vitamin B_1 has been synthesised and is known as thiamine

come into some prominence lately because white bread is made after the germ and the husk have been removed B_1 is important because it is probably concerned in the metabolism of carbohydrate It seems likely that pyruvic acid is metabolised to lactic acid and acetic acid by B_1 It is also thought that normal digestion and *absorption* from the bowel depend to some extent on this vitamin, and it is now used extensively in intestinal disorders in man on this basis

Deficiency in animals leads to anorexia, atrophy of lymphoid tissue and lymphopenia Absorption of fat is impaired, passage of food along the bowel is delayed and putrefaction occurs in the intestine Bradycardia is found, and polyneuritis is described For this reason the vitamin is now extensively used in man, but the analogy is not a close one Chronic alcoholism is associated with deficiency of the vitamin Œdema of uncertain origin is occasionally improved by its use

The use of vitamin B_1 in rheumatoid arthritis has been advocated (Fletcher, 1936) Therapy of this type is mostly advocated on the basis of its effect on the bowel and extensive X-ray studies have been carried out to show the abnormalities that may be encountered in arthritis Such symptoms as a red sore tongue and loss of appetite appear to be relieved Injections of the vitamin have sometimes led

B_3, B_4 and B_5 are thought to exist on experimental proof

Deficiency of riboflavin leads to certain skin lesions, some affections of the eye, including keratitis Nicotinic-acid deficiency leads to pellagra Vitamin B_6 is concerned in nutrition and is said to relieve the tremor of certain extra-pyramidal lesions, as well as diminishing the spasticity.

In practice one often finds vitamin B being prescribed for rheuma- arthritis, but *experimental or physiological evidence for its use be entirely lacking*, unless there is definite dietary deficiency, vement can seldom definitely be attributed to its use It er, be remembered that storage of vitamin B is minimal ody depends on the daily intake

been synthesised and is known as ascorbic acid. It

carried out and allowance was made for the water in the food as well as that actually drunk. He also allowed for water formed from the combustion of carbohydrate, protein and fat. Using a simple intake-output chart, and not allowing for these additional factors, no marked abnormality has been found, provided kidney function is normal. The use of thyroid extract in these cases has only slightly increased the output.

The Vitamins

Vitamin deficiency has often been quoted as instrumental in producing arthritis and this idea has been revivified in America with the introduction of massive dosage of vitamin D (ertron) This question of vitamin deficiency in rheumatoid arthritis is a constantly recurring one, so it may be as well to state something of what is known of the vitamins and to discuss the likelihood of their being concerned in the process.

Vitamin A.—This is found in maximum concentration in halibut oil, good amounts are found in *animal fats*, e g cream, milk, butter, eggs, meat fats and cod-liver oil It is *absent* from fats of vegetable origin and from lard. The vitamin A in the body is all derived from the food and is supplied as the vitamin itself or as carotene, which is converted to vitamin A in the liver.

Deficiency under experimental conditions leads to death from *intercurrent infection so that vitamin A has been called the anti-infective vitamin*. This is somewhat of an over-statement but no doubt vitamin A plays a part in the defence against infection. The specific indication of deficiency is *xerophthalmia* The salivary glands atrophy and the glands secreting mucus in the intestine are found filled with cells and organisms The whole tendency is to leave *areas of focal sepsis*, resulting in a bacteriæmia, leading to *bronchopneumonia and other infections* This diminished resistance to, and greater risk from, infection has been proved experimentally, and was confirmed in man during the last war. It is said that deficiency may lead n [illegible] but also to *pulmonary tuberculosis*, [illegible] *night blindness* are also found. There [illegible] ition is due to lack of the vitamin and degrees of dark adaptation have been used as a test to demonstrate it. Apart from certain changes in the central nervous system, Mellanby (quoted by Samson Wright) has recently found marked thickening of various bones and believes this leads to *compression of nerve roots* Joseph Race (1937) measured plasma pigments, carotene and vitamin A *He found carotene to be* diminished in rheumatoid arthritis, as also vitamin A (25 per 100 ml. as compared with 90 in the controls). None of the changes mentioned under the heading of "deficiency" occur in arthritis with the exception of foci of sepsis, but these changes are all evidence of *very marked* deficiency, and a lesser deprivation may produce other changes, not so far understood. Attempts to treat cases with doses of the vitamin *up to 70,000 units a day have not proved successful* either here or in

to vitamin D_3 The second *deficiency syndrome* is concerned with the structure of the teeth, and is probably interwoven with a deficiency of vitamins A and C. An excellent description will be found in *Applied Physiology* (Samson Wright, 1942).

Vitamin D probably acts by promoting the absorption of calcium and phosphate from the bowel

Dreyer and Reed (1935), working on vitamin D and hay fever, found that two patients with rheumatoid arthritis showed considerable improvement They followed this up giving 5 mg of calciferol daily for a month or more They found both rheumatoid and osteo-arthritis to be improved Since then, a great many therapeutic trials have been carried out, and as Comroe says "preparations of all potencies have been over-emphasised and over-sold to the public "

In 1942 Reynolds published a trial with "Ertron " a vitamin D preparation made by passing an electric current through vaporised ergosterol He claimed that this preparation had a different effect from vitamin D It is generally thought now to be identical with calciferol (D_2) The Council on Pharmacy and Chemistry of the American Medical Association took this preparation off the list of new and non-official remedies They thought its effect was non-specific and might be toxic in such large doses, but it has recently been restored In a small trial of 20 cases of rheumatoid arthritis treated with 50,000 units of vitamin D, three times a day, the following results were obtained Ten were improved over six months (two weeks on treatment and two off) to the point of being able to go to work Two were improved clinically as judged by joint swelling and sedimentation rate Eight were approximately in a stationary condition, but none were definitely worse (although two had to stop treatment) Taking the two improved groups together, twelve out of twenty showed some success (60 per cent) The percentage of "success" obtained without regard to the duration of the disease or the method of treatment in rheumatoid arthritis I have found to be 64 4, per cent , so there is some little ground for thinking that vitamin D compares on an equal footing with other treatments The percentage of "success" obtained in a refractory condition like osteo arthritis of the hips, where treatment is of little avail was 34 9 per cent No toxic results have been seen except nausea and vomiting of a fairly marked severity (two cases) and transient nausea in several cases No renal damage ensued, as judged by chemical tests of the urine Some authors say that the dosage used here is insufficient to produce maximum results

Overdosage of vitamin D is said to lead to symptoms like hyperparathyroidism Hypervitaminosis may ensue if a high calcium diet is taken Anyone who wishes to undertake this form of treatment should read the original papers concerned (Snyder *et al* , 1943, Farley *et al* 1941)

Vitamin E —Is a tocopherol with two forms (α and β) Is *found* in the embryo of wheat, and in seeds and green leaves

The *deficiency syndrome* consists, in rats, of a failure of development after the fertile ovum has been normally implanted in the uterus

is found in fresh foodstuffs, *fruit juices like orange and lemon*, in vegetables, and just under the skin of potatoes It is now possible to preserve fruit by canning it under anaerobic conditions.

The typical *deficiency syndrome* is scurvy and the specific *pathological change* is the failure to maintain normal intercellular ground substance This is especially *noticeable* in the collagen of fibrous tissue and the matrix of bone, cartilage, dentine, and the non-epithelial cement substance of the lining of the blood capillaries. The hæmorrhages so commonly found in scurvy are explained *on this basis*

Investigating the question of vitamin C in the blood, Race (1937) found that the blood level varied to a great extent with the diet He found, however, a lowered value in all classes of rheumatic cases, rheumatoid and osteoarthritis, as well as fibrositis and a group he called sub-acute rheumatism From this he concluded that, as osteoarthritis is non-infective in origin, a deficient diet must operate in all these cases. On further investigation, however, he found that feeding ascorbic acid to the arthritic patients produced a lesser rise in the plasma level than in controls. He was unable to decide whether this was due to variable absorption or to increased destruction Although balance experiments would be difficult, if possible they would be helpful. Somewhat similar results have been found in children suffering from acute rheumatism Some people regard this as the result of the disease and not part of its cause. Comparable results have been obtained in several other infectious diseases.

In 1935 Rhinehart produced an experimental scorbutic arthropathy in guinea-pigs, which somewhat resembled rheumatoid arthritis, but on the whole they are not strictly comparable Race emphasises the connection of vitamin C with the ductless glands and thinks that its rôle in the corpus luteum may be important, for Mouriquand and Schoen (1933) found that scurvy cannot be artificially induced into pregnant women He thinks that the remission of symptoms during pregnancy may be connected with this

Although it is fairly clear that lack of vitamin C is not the cause of rheumatoid arthritis, it may well be one of the factors concerned in its production

Vitamin D can be prepared from ergosterol by irradiation by ultra-violet rays This is sometimes known as D_2, preparations from tunny-fish oil are known as D_3, and may be identical with the natural vitamin

It is *found* in cod-liver oil, in halibut oil and in yolk of egg, also to some extent in animal fats, but is absent from vegetable oils

The principal *deficiency syndrome* is rickets The bones are soft from an insufficiency of calcium salts and become deformed Ossification is retarded because the older cartilage cells do not degenerate and the blood vessels and osteoblasts of the shaft cannot penetrate This unusual survival of the cartilage cells leads to the broad and rugged epiphyseal line The level of serum calcium or of phosphate *or of both* is lowered. Rickets can, however, be cured even on a deficient diet by exposure to ultra-violet rays These rays act by converting an inactive sterol (7 dehydrocholesterol) found in the skin

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Administration of vitamin E at this stage saves the fœtus. It has therefore been used for women who suffer from habitual abortion. In the male rat, atrophy of the seminiferous tubules occurs

It is mentioned here because it is said that the muscular dystrophies and possibly some forms of muscular atrophy are also part of the deficiency syndrome and that administration of α-tocopherol relieves them This form of therapy in two cases of muscular dystrophy had some beneficial effect, but its value in rheumatoid arthritis is very doubtful

Vitamin K—Is partly responsible for the prothrombin level in the blood. In 1941 Rawls reported a low prothrombin level in 50 *per cent of cases of rheumatoid arthritis* Vitamin K restores the prothrombin level

The Neurogenic Theory

Tegner (1939) records that a group of workers at Aachen agree that all chronic rheumatic diseases can be associated with the presence of septic foci. In the case of rheumatoid arthritis the toxins from these foci are said to attack the joints through the central nervous system They say [illegible]
the anterior horn [illegible]
and capillary spasm [illegible]
the joints They claim that rheumatoid arthritis is a form of chronic anterior polyomyelitis and that muscular fibrillation can be demonstrated in the small muscles of the foot in all cases. It is very tempting to regard some of the features of the syndrome as due to involvement of the central nervous system, and it has been said that its bilateral tendency is in favour of such an idea So far, there is nothing approaching proof of such a thing.

The arthropathies of tabes and syringomyelia are an entirely separate consideration

The *capillary spasm* mentioned above has been thought important by some writers and a good deal has been written as to its relationship with cold and damp, and a constitutional liability to arthritis

Fox and van Breemen devote a chapter to its consideration and quote Pemberton as thinking that many capillaries were narrowed, that there was a slowing in the blood flow, and that a difference existed in the amount of blood in the venous and arterial limbs of the capillaries.

Photographs of nail-bed capillaries seem to indicate some differences in rheumatoid arthritis, and the benefit obtained from heat treatment is a noticeable feature. The matter has been mentioned in Chapter VI.

The Effect of Weight-bearing on the Incidence of Rheumatoid Arthritis

[illegible]

Statistical examination [illegible]
this is not a potent factor.

AGE DISTRIBUTION BY JOINT AFFECTED

Ages	Hands		Knees		Hips		Shoulders		Feet	
		%		%		%		%		%
0 –	17	10.7	2	3.8					3	9.7
25 –	29	18.2	9	17.0	2	11.8	6	20.7	6	19.4
35 –	29	18.2	8	15.1	2	11.8	5	17.2	7	22.6
45 –	46	28.9	15	28.3	5	29.4	9	31.0	8	25.8
55 –	25	15.7	12	22.6	7	41.2	6	20.7	7	22.6
65 –	13	8.2	7	13.2	1	5.9	3	10.3		
	159	99.9	53	100.0	17	100.1	29	99.9	13	100.1

Without statistical tests it is evident that there are no noteworthy differences between the percentage distributions, but tests do prove there are none

Ages	Hands		Knees and Hips	
		%		%
Under 35 –	46	28.9	13	18.6
35 –	29	18.2	10	14.3
45 –	46	28.9	20	28.6
55	38	23.9	27	38.6
	159	99.9	70	100.1

This table indicates quite clearly that, taking weight-bearing joints on one hand (knees and hips) and comparing them with joints which bear no weight (hands) on the other, no great difference has been found This inquiry was instituted in order to discover whether, in susceptible persons, weight-bearing could influence the incidence of rheumatoid arthritis It appears that this factor is not significant It can be deduced that microtrauma is not a factor, even in susceptible persons

PATHOLOGY OF RHEUMATOID ARTHRITIS

General Considerations

Two important advances have been made within recent times in the pathological study of rheumatism. Firstly, it has become more clearly recognised that just as clinical pictures are not necessarily specific, so histological pictures may be merely pattern reactions to many stimuli Secondly, an elementary basic pattern has been

detail as to which is the primary *change*. *From* a study of subcutaneous nodules in rheumatoid arthritis Collins believes that proliferation of connective tissue precedes degeneration, but some think the primary change is a *fibrinoid* degeneration, followed by mesenchymal proliferation and invasion of *leucocytes*. *This point* may at a later stage become extremely important. The typical example of the above process is the Aschoff nodule.

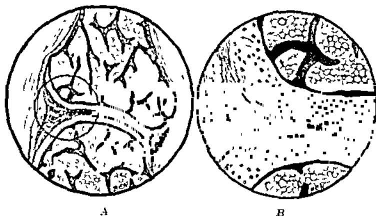


Fig 77

A Low-power view of pannus commencing to creep along the articular surface

B High-power, same view *Pathology of Rheumatoid Arthritis* (after Nichols and Richardson)

The attempt to base an allergic theory of rheumatism on the similarity with the tissue changes in hypersensitive animals is not apparently justified. Collins (1937) is not prepared at present to assume the identity of the nodules in rheumatic fever and rheumatoid arthritis on the similarity of the tissue change, and quotes similar changes in other conditions. (See Subcutaneous Nodules.)

The pathology of rheumatoid arthritis must be regarded as a dynamic chain of events, commencing with small-celled infiltration of the synovial membrane, with proliferation of endosteum and gradually the process spreads, but at any time it may be partially or completely arrested.

Synovial Tissue and Articular Cartilage

Macroscopically there is a great hypertrophy of the synovial villi, which appear to bulge out of the joint when it is opened. These show signs of inflammation and hæmorrhages occur into *them*. Sometimes opposing layers of synovial membrane stick together, and the membrane may adhere to the articular cartilage. As healing and fibrosis occur, contraction takes place, leading to joint deformity

[illegible] result of *long*-continued inflammation

[illegible] only be a red congested membrane

[illegible] with only a few fringes. Gradually



Fig 78

General view of rheumatoid synovial membrane, showing two round celled foci, and the general vascularity

Pathology of Rheumatoid Arthritis (Dr J W Shackle)

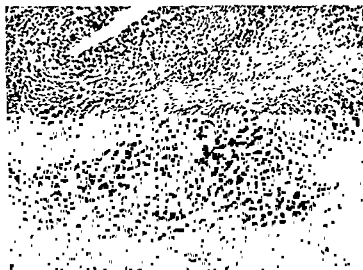


Fig. 79

Higher magnification of a focal collection of lymphocytes in the synovial membrane, showing a fold of the endothelial lining

Pathology of Rheumatoid Arthritis (Dr J W Shackle)

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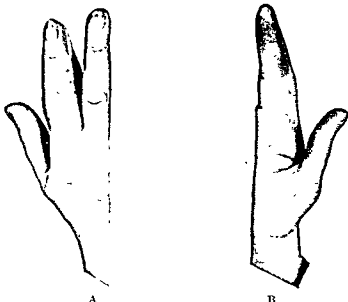


Fig 83

A To compare with Fig 82 The index finger is more evenly swollen, and the fusiform appearance is largely lost This is an appearance not often seen Sedimentation rate was 45 mm at the hour, and blood uric acid 2 9 mgrm per 100 ml

B. See Fig 83A

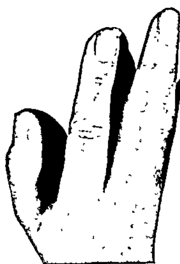


Fig. 84



Fig 85

Fig 84 —An atypical case of rheumatoid arthritis resembling Fig 83 This is an early and acute case before muscle-wasting occurs.

Fig 85.—To compare with Fig 84

infection, such as a cold or a mild attack of nasal sinusitis This occurs too frequently to be ignored, and even after treatment, and a period of remission, an exacerbation may start in the same way The patient complains of easy fatiguability and a general feeling of malaise Loss of appetite and loss of weight may go hand-in-hand, or loss of weight may be so marked as to raise a suspicion of tuberculosis Hench (1941) estimated that it might be as great as 50 per cent of the whole body The asthenic build and spare habitus go with the pale sweating skin and the cold clammy hands Muscle weakness and a poor circulation are associated with vasomotor instability A low blood pressure and

over the body, or only in the neck The tip of the spleen may at a later stage become palpable Subcutaneous nodules appear around the elbow joint and along the border of the ulna Ganglia and synovial protrusions commonly occur The X-rays show two main characteristics decalcification or osteoporosis, and loss of joint space, generally from cartilage loss

The sedimentation rate is usually raised in rheumatoid arthritis. In 744 cases statistically analysed the rate was raised in 64 per cent of cases of rheumatoid arthritis as against 9 per cent in fibrositis and 11 per cent in osteoarthritis (Fletcher *et al*, 1945)

FREQUENCY DISTRIBUTION OF THE BLOOD SEDIMENTATION RATE WHEN TREATMENT COMMENCED, FOR SPECIFIED TYPES OF RHEUMATISM

	R A	*Ankylosing Spondylitis*	*Gout*	*Fibrositis*	*O A Spine and other Joints*	*O A Hips*	*Total*
Cases below 15 mm at the hour	83	21	25	101	243	39	512
Cases above 15 mm at the hour	145	29	14	10	31	3	232
Total	228	50	39	111	274	42	744
Percentage where B S R is 15 mm or over	64 per cent	58 per cent	36 per cent	9 per cent	11 per cent	7 per cent	31 per cent

The white-cell count may be slightly raised with a shift to the left in the Arneth count If an effusion occurs some fluid should be aspirated and a cell count carried out. The usual total cell count is over 10,000 per c mm , with a large proportion of polymorphonuclears.

Agglutination of streptococci in high titre by serum from rheumatoid patients has often been found It does not, however, appear at the present time to be a test of great practical routine use The types of streptococci are too numerous

Weltmann coagulation test was first described in 1930 As it has

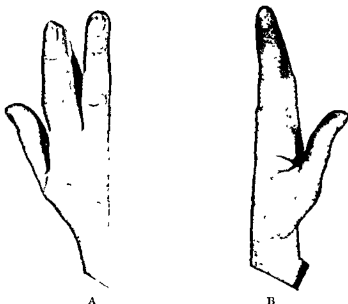


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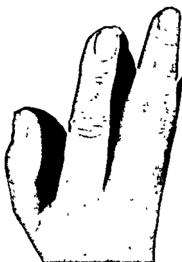


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Weltmann coagulation test was first described in 1930 As it has

been found to be of some use in arthritis it may be as well to describe the technique first, but as this is rather troublesome, a simple *modification will also be described*

A stock solution of 10 per cent crystalline $CaCl_2 \cdot 6H_2O$ is kept, and from this 10 dilutions are prepared in 10 test-tubes on a rack, *ranging from 1 1000 to 1. 1000.* The difference between each tube is ·1 1000, so that the fifth tube from the left contains ·6: 1000. Each tube contains 4·9 ml. of solution The highest concentration *stands on the left.*

To each tube is added 0·1 ml of clear non-hæmolysed serum.

The tubes are shaken and *heated in a water-bath for* 15 minutes. After heating they either remain clear or *show flocculation* In normal



Fig 86

The nodules on the fingers of the rheumatoid case



Fig 87

The skin atrophy often seen

sera flocculation occurs in tubes 6 or 7 counting from the left. If it occurs only in tubes 1–5, it is called a short band, or exudative zone; ... tube 8 or further, it is called a long band, or fibrotic zone.
ic disease and exudative
enerally regarded as a
degenerative disease It therefore seemed likely that Weltmann's reaction might be useful in separating the two

A simple modification of the test was used by Kling (1941) A single tube was used and 4·9 ml of distilled water and 0·1 ml. of clear non-hæmolysed serum was placed in it. Add from *0 1 ml pipette* 0 05 ml. of 1 per cent calcium chloride Shake and boil. Cool and repeat the procedure until flocculation takes place. Note the amount used.

... the conversion is shown
nd the number

WELTMANN'S METHOD

Tube	1	2	3	4	5	6	7	8	9	10
$CaCl_2$/1000	1 0	9	·8	7	6	5	·4	3	·2	·1
Mgm $CaCl_2$/5 ml	5 0	4 5	4 0	3 5	3 0	2 5	2 0	1 5	1·0	0 5
Modification ml of 1 per cent $CaCl_2$	0 5	0 45	0 4	0 35	0 3	0 25	0 2	0 15	0 1	0 05
	Exudative zone					Normal zone		Fibrotic zone		

Ninety-eight cases of rheumatoid arthritis, eighty-eight cases of osteoarthritis, and sixty-four miscellaneous types were tested.



FIG 88

Ankylosis of the proximal phalangeal joints



FIG 89

The long hypotonic hand and fingers with fine, smooth skin which used to be regarded as the hall-mark of the 'classical' rheumatoid case

Kling concluded that the test did not possess the general utility of the sedimentation rate, and was not such a good check on the clinical course of the disease In osteoarthritis this was particularly noticeable On the other hand there were cases where the Weltmann was more accurate and in some cases it led to the discovery of exudative or fibrotic processes not revealed by the sedimentation test

For instance, such complications as exudative tuberculosis and hepatic cirrhosis were first indicated by the coagulation band

It seems a reasonable view, now that the test has been simplified, to use it alongside the sedimentation test

Formol-gel reaction gives a qualitative test for increase of globulin or fibrinogen in the blood It may be of use where the sedimentation

pends
He

found that rheumatic patients showed a drop in the leucocyte count after thirty minutes; non-rheumatics did not.

Copeman *et al.* (1942) *studied this* work and were not able to confirm the findings Recent American work is in favour

Blood chemistry.—The blood chemistry is essentially normal, occasional alterations in blood proteins are found and the cholesterol level may be low

Course of the Disease

This varies from a progressive crippling with bouts of fever and tachycardia to a mild condition involving one or two joints without



Fig 90



Fig. 91

Figs 90 and 91 A very advanced and long-standing case of rheumatoid arthritis Note the collapse of the carpus in the X ray on the left

constitutional symptoms, and becoming arrested with perhaps one or two joints deformed

Presumably the disease has a natural course and it almost certainly has a natural tendency to recovery. In a statistical study of the percentage of success in treatment without regard to the duration of the disease, or the method of treatment, the percentage of "success" in osteoarthritis of the hips was 34 9 per cent. As is well known, this condition is for all practical purposes refractory to treatment, so this figure may represent the natural tendency to remission of one of the rheumatic diseases. If this is so, it may be a figure which could be

by remissions and relapses, and in setting a base line from which to determine "success" in treatment the relative proportion of each may be unbalanced.

remission is followed by the involvement of more joints, but rather unexpectedly these cases sometimes clear up wonderfully well

Complications and Unusual Features

Lymphadenopathy and *enlargement of the spleen* have been mentioned If the glands are unusually large and numerous they may cause difficulty in diagnosis Biopsies show no characteristic features but there is usually degeneration of lymph follicles. Such glands fall into the same category as those occurring in any chronic infective disease *Cardiac lesions* may develop in the course of arthritis. Mitral stenosis is the usual lesion

Scleromalacia perforans is a condition first reported in 1934 by Van der Hoeve In 1940 Eggers described a case in a woman of 37 years, and it seems likely that the condition is a true inflammation and forms part of the syndrome of rheumatoid arthritis In Eggers' case polyarthritis was associated with a sedimentation rate of over 100 mm at the hour Later three scleral abscesses formed, and bilateral uveitis with vitreous hæmorrhage destroyed the sight. Verhoeff and King called the condition necroscleritis nodosa, and said the scleral histology resembled that of the subcutaneous nodules found in rheumatoid arthritis Duke-Elder (1938) says that the disease is characterised by the appearance of holes in the sclera without dominant signs of inflammation Although a yellow excrescence occasionally appears early, no pus is found *Iritis* has also been described

Gastro-intestinal Features

It is a common experience that patients with arthritis complain of dyspepsia, and no doubt in a good many cases the build of these patients is of the asthenic ptotic type These facts probably led Fletcher and Graham (1930) to make extensive radiographic studies of the alimentary tract Fletcher found various X-ray lesions in the colon, especially delay, and noted he could improve this with administration of vitamin B However this may be, there are no known and constant gastro-intestinal complications of rheumatoid arthritis

Peripheral nerve lesions are said to exist in arthritis, small nodules occurring in the perineurium (Freund, 1942) Histological appearances are described and it is said that similar nodules may be found in the muscles (see Pathology)

B coli pyelitis —This is a common complaint amongst the population as a whole but it seems to occur with great and unusual frequency in cases of arthritis Some people regard it as a type of focal sepsis

head pillow, but a pillow is placed under the shoulders and another under the knees. Hands are placed under the back of the head. If this *position is maintained for half* an hour after meals, the circulation will be improved

The reverse position is prone with a pillow under the abdomen only

In addition, any of the more usual types of breathing exercises may be carried out morning and evening.

Remember *not to keep pillows* under the patient's knees in bed There is no more certain way to produce flexion deformity (Fig 92).

Care of the skin should include tepid sponging of the body once a day, and woollen garments should be worn in bed Good nursing is essential, and the patient should be so nursed that every muscle is relaxed Only too often one sees patients in bed with shoulders bent forward and head held erect, most of the muscles in the upper half of the body being in tension

Oxygen tents have been used, and often lead to subjective improvement It is not, however, a measure which is physiologically sound, for in arthritis the difficulty with oxygen utilisation does not occur

Prolonged bed rest is as harmful as insufficient rest. Figs 93, 94 and 95 show the decalcification and ankylosis which followed eighteen months' complete bed rest The joints must all be put through a complete range of movement each day and the exercises already mentioned carried out conscientiously.

DIET

This question comes next in importance to rest. With a disease in which the katabolic element is so much stressed, it is evident that, so far as is possible, the calorie intake should be in excess of bodily requirements

It is as well to have a practical clinical guide as to the number of calories each patient really requires For this purpose reference should be made to a standard weight chart which will give the average weight for a patient of *that sex, age and height. Taking this average* weight the total calorie requirement may be estimated by multiplying the weight in pounds by 16

To take an example A woman aged 26, 5 ft 6 in in height, should on an average weigh 135 pounds, multiplied by 16 this gives a caloric requirement of 2,160, and in such a case a diet of 500–1,000 calories in excess should be prescribed e g between 2,700 and 3,200. Taking 3,000 as our aim, the following diet would meet our requirements

Carbohydrate	—	290 grams
Protein	—	70 „
Fat	—	175 „
Calorie value	—	3,015 „

BREAKFAST			*Grams*
Fruit	—	1 serving	100
Cereal (cooked)	—	2/3 cup	140
Bacon	—	2 slices	10
Egg	—	1	50
Bread (toast)	—	1 slice	30
Butter	—	2 squares	20
Sugar	—	1 tablespoon	15
Jam or jelly	—	2 tablespoons	30
Cream, 20 per cent	—	½ glass	100
Milk	—	½ glass	100
Beverage—coffee, tea, or coffee substitute			
10 A M			
Fruit juice	—	1 glass	200
LUNCHEON			
Egg or egg substitute	—	1 serving	50
Potato or substitute	—	1 small serving	75
Vegetable	—	1 serving	100
Salad Vegetable	—	1 serving	100
Salad dressing with oil	—	1 tablespoon	15
Bread	—	1 slice	30
Butter	—	2 squares	20
Fruit	—	1 serving	100
Cream, 20 per cent	—	¼ glass	50
Milk	—	¾ glass	150
3 P M			
Fruit juice	—	1 glass	200
DINNER			
Meat	—	1 serving	60
Potato	—	1 small serving	60
Vegetable	—	1 serving	100
Salad Fruit	—	1 serving	100
Salad dressing with oil	—	1 tablespoon	15
Bread	—	1 slice	30
Butter	—	2 squares	20
Dessert	—	1 serving	100
Cream, 20 per cent	—	¼ glass	50
Milk	—	¾ glass	150

Some authors (Copeman, 1939) try to establish in the tissues an alkaline bias, after which the diet as above is allowed to alternate with a "full but purely alkaline producing diet"

In this connection, it may be as well to say that an alkaline-producing diet is one which has an alkaline ash and includes such foods as fruits, vegetables, milk and sugar

It is quite easy therefore to arrange, say, an "alkaline" breakfast with milk, suitably sweetened, and various kinds of fruits, but it is rather more difficult to raise the caloric requirement on such a diet, as it is necessary also to raise the bulk of food eaten, and cream meets this difficulty well

Auxiliary and Accessory Food Factors

If it is found that the poor appetite of the rheumatoid patient defeats the attempt to raise the food intake, it is sometimes possible to improve matters by adding "between-meal" feeds, and these usually take the form of milk, cream, eggs and fruit juices, and occasionally chocolates. It is sometimes useful to cut down the bulk of the diet by reducing the vegetable side Foods rich in iron and calcium are useful, with a high vitamin content. Examples are: liver and kidney, eggs, spinach, milk, cheese and fruits

In a diet of this sort, vitamin intake is obviously adequate, but some like to add vitamins to the diet, and this may be done with cod-liver oil, "Bemax," "Marmite," or some preparation, like "Multivite" pellets (B.D.H), which contains vitamins A, B, C and D; but on the whole concentrates of vitamins A and D are not very satisfactory. Some authorities have suggested a "dehydration" diet, i e. a diet rich in protein and poor in fat and carbohydrate, free from salt and low in fluids It is usual with such a diet to give 50 g of urea a day This cannot be recommended.

but it may be increased to fifteen or twenty with caution A good many people think that insulin does not serve its purpose unless given in really large doses, and recommend 30–40 units twice a day, or even more A good deal more has been heard of this since psychiatrists reported that their patients treated with insulin shock showed a considerable improvement in their general health as well as a greatly increased appetite Occasionally it happens that a patient does not respond to the lower doses of insulin, presumably because a lowered blood sugar does not lead to increased appetite, but no experience can be reported of the larger doses of insulin.

Blood Transfusions

There comes a time in the treatment of a good many cases of arthritis when it seems that the progress of the disease has been arrested, but no actual improvement is being made. This is a very troublesome period and on some occasions blood transfusions provide a way out of the difficulty. Small transfusions are used and repeated once or twice, but provided there are no contra-indications it seems a better plan to give a full transfusion of one pint with actual cross-testing done at the time of the transfusion. This can be repeated in two weeks if necessary

The Indications for Terminating Bed Rest, and getting the Patient up

1. *Settling of temperature* and *slowing of pulse rate*.—In some intractable cases the pulse rate remains at a high level, although the temperature has settled. It is sometimes wise to get the patient out of bed in spite of this, provided it is established that the heart is normal, and that the case is not one of rheumatic fever.

2 In those cases where *anæmia* is a troublesome feature, prolonged bed rest sometimes makes the patient worse It must be clear that the anæmia has no other cause before the patient is allowed up

3 *Impending ankylosis* can sometimes be delayed or prevented by getting the patient up

4 Any general improvement can be suitably encouraged by allowing more freedom



Fig 92

To illustrate the flexion deformity which may follow prolonged bed rest with supporting pillows under the knees

5 Threatened bedsores are a clear indication unless the patient is extremely ill

6 Some patients do very badly in bed, due notice must be taken of the type of patient

7 Marked muscle-wasting which cannot be checked by exercises and physiotherapy

8 Persistent constipation which does not yield to abdominal massage, mild aperients, and faradism to the abdominal muscles

9 A poor appetite which cannot be encouraged by tonics or even insulin

Bed rest should not be allowed for longer than is absolute necessary

If Prolonged Bed Rest is unavoidable

1 Keep a cradle over the legs and let the feet rest against a board to prevent foot-drop



Fig 93



Fig 94
The Shoulder Joint



Fig 95
Knee Joint

Figs 93, 94, and 95
To show decalcification and ankylosis after 18 months in bed



Fig 96
Rheumatoid arthritis of the tarsus
Note the flat foot

2 Give general massage and small doses of ultra-violet light
3. Nurse the patient alternately sitting up and lying down
4. See that the bed does not sag in the middle

Relief of Pain

Drugs—Aspirin or A P C tablets are the most frequently used On the whole, either Veganin or some other compound of aspirin with codeine is preferable, as the added codeine seems to enhance the effect Empirin Compound with codeine is my own preference (B W & Co) Some prefer calcium aspirin Some patients can take aspirin in a pot cit mixture only

Dilaudid in tablet form 0 01 gram (Knoll) is a non-habit-forming morphine compound It is effective. Pethidine is much used

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OTHER DRUGS COMMONLY USED

Tonic treatment—As a secondary anæmia is such a common accompaniment of rheumatoid arthritis, *iron* is nearly always required, and either Fersolate tablets or Tabloid Blaud pills are effective Of

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but

the iron content must be stepped up

Calcium—Because the X-ray findings in arthritis often include decalcification and thinning of the bones, calcium is much used There is no biochemical justification for this as the calcium balance is normal but some subjective improvement is said to follow its use

If given by mouth calcium wafers are generally used (Parke Davis Content of calcium in each wafer 15 grains)

By injection, calcium gluconate is probably the best, a 10 or 20 per cent solution is generally used This is now put up by several firms Another good preparation is Colloidal Calcium with Ostelin D (Glaxo) One c c or more twice weekly is the usual dose

Thiohistamine is given by intramuscular injection, and acts on the capillaries The usual dose is 0 001 gram, increased by the same amount for the succeeding three or four injections given on consecutive days If more than one course is given four weeks must be allowed to elapse between In practice thiohistamine sometimes leads to faintness and giddiness, but no permanent bad effects have been noticed Occasionally it seems to lead to greater freedom of *movement and relief of pain, but this is usually temporary*

Vitamin preparations are used very largely (see above) So far as is known, on a good mixed diet, there is no lack of vitamins in arthritis, but Abbasy, Harris and Ellman (1937) showed by vitamin C satura-



Fig 94
The Shoulder Joint



Fig 93

Figs 93, 94, and 95
To show decalcification and ankylosis after 18 months in bed



Fig. 95
Knee Joint





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Local applications.—These are innumerable, but most of the applications contain oil of wintergreen and/or turpentine Bengue's Balsam is a soothing application, and Azochloramide is useful

OTHER DRUGS COMMONLY USED

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If given by mouth calcium wafers are generally used (Parke Davis Content of calcium in each wafer 15 grains).

By injection, calcium gluconate is probably the best, a 10 or 20 per cent solution is generally used This is now put up by several firms Another good preparation is Colloidal Calcium with Ostelin D (Glaxo) One c c or more twice weekly is the usual dose

Thiohistamine is given by intramuscular injection, and acts on the capillaries The usual dose is 0 001 gram, increased by the same amount for the succeeding three or four injections given on consecutive days If more than one course is given four weeks must be allowed to elapse between In practice thiohistamine sometimes leads to faintness and giddiness, but no permanent bad effects have been noticed Occasionally it seems to lead to greater freedom of movement and relief of pain, but this is usually temporary

Vitamin preparations are used very largely (see above) So far as is known, on a good mixed diet, there is no lack of vitamins in arthritis, but Abbasy, Harris and Ellman (1937) showed by vitamin C satura-

is that the storage capacity for this vitamin is limited; and as it is unlikely that the body can synthesise it, it seems that we depend on our day-to-day intake. Probably the low blood vitamin C levels are more associated with long, chronic debilitating illnesses than with rheumatoid arthritis

The vitamin can be given by mouth in tablets containing 50 mg The initial dose should be five tablets daily and after a week this can be dropped to two. Personally, I have seldom seen any good result come from this treatment.

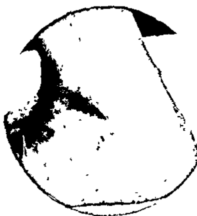


Fig 97

A nodule under the Tendo achilles, this is a fairly common finding in rheumatoid arthritis It does not necessarily indicate gonococcal infection as some authorities suggest

Vitamin D.—A great deal of work has been done on this vitamin in America.

As the treatment of arthritis with massive doses of vitamin D has been largely recommended in the U S.A., a section on vitamin D and its action is incorporated in the chapter on Ætiology.

Action of vitamin D.—It promotes the absorption of calcium and phosphorus from the bowel, so that in the absence of the vitamin the blood-levels fall.

It is almost certainly necessary for the calcification of bone, but it is uncertain whether this is simply because the blood-level falls, and so less is taken to the bones, or whether there is some more direct action.

If the vitamin intake is low but just sufficient, symptoms of avitaminosis may be precipitated by increase of the cereal content of the diet, e g by adding bread. This is alleged to be due to phytic acid, which interferes with absorption of phosphate.

The vitamin D content of various foodstuffs is as follows:

Cod-liver oil—500 units per drachm.
Halibut-liver oil—50 units per drop.
Milk—50 units per pint
Butter—10-100 units per ounce.
Eggs—60 units per yolk (Samson Wright, 1942)

The vitamin requirement of an adult is not known, but a good deal of the vitamin is obtained from the action of sunlight on the skin. On the other hand, as can be seen from the content of the vitamin-containing foods, the intake in the diet is relatively small.

Vitamin D is probably not a single substance Rather like the œstrogens, a group of substances have the same or similar action

The use of vitamin D in arthritis—After Dreyer and Reed's original work in 1935, vitamin D in massive doses was used in arthritis by many workers both in the U.S A. and in this country.

In 1942, Reynolds claimed that a preparation known as *Ertron* differed from vitamin D in toxicity. This preparation is manufactured by heating ergosterol until it becomes a vapour and then passing an electric current through it. It is not yet quite certain what the final product is, but the general opinion seems to be that it is identical with calciferol. Opinion is divided as to the effect of this drug in arthritis. Some authors claim a very high percentage of cures, going up to 100 per cent, whilst others are doubtful. Boots (1943) in a very careful paper dealing with his work at the Arthritis



FIG 98

Rheumatoid arthritis Note the fusiform swelling of the knee



FIG 99

Rheumatoid arthritis of the knees

(X-ray is shown in Fig 99)

Clinic at the Presbyterian Hospital found only one patient out of thirty to be improved, and noted that nausea and vomiting was a prevalent feature of the treatment. In my own small series of twenty, ten were improved after six months' treatment as judged by their capacity for work, and two were improved but not able to work. As mentioned in the chapter on Ætiology, this compares on an equal footing with most other treatments (except gold). The only toxic results noticed were a feeling of malaise (quite marked on occasion), nausea and vomiting. Two cases had to give up the treatment on this account. The dosage used was 50,000 units three times a day (Glaxo preparation). Some authors think that this dosage is too low, and advise 100,00[illegible]
manufacturec[illegible]
cases, which[illegible]
of opinion that the treatment may raise the serum calcium.

Only one author was of opinion that renal damage followed the treatment. Freeman *et al* (1946) are of opinion that severe renal insufficiency may result from doses of Ertron such as are commonly given in the United States of America for arthritis (e g 300,000 units daily). One child with rheumatoid arthritis showed *reduced* calcium retention after treatment.

Some patients treated with Ertron were given one or two quarts of milk a day Such a high calcium and phosphorus intake makes the possibility of intoxication with Ertron much more likely Calcium deposits were found in the soft tissues by X-ray and disappeared after the Ertron and milk was discontinued.

The opinion is expressed that the administration of vitamin D should be checked by biochemical tests Suitable tests would be blood non-protein nitrogen, blood calcium and phosphorus, and tests of renal function Calcium balance tests would be ideal, but are difficult, tedious

Comroe says

the *ultra-violet t*

has been suggested that a glass of milk three times a day might avoid these reactions. It may be for this reason that milk was administered so lavishly with Ertron So far as is known, arteriosclerosis is the only contra-indication to vitamin D

Rawls (1941) reported a hypoprothrombinæmia in nearly half the patients suffering from rheumatoid arthritis. It is not possible at present to estimate the significance of this but *vitamin K* restores the prothrombin level.

Calcium ortho-iodoxybenzoate —This is one of the iodine substitution products of benzoic acid Originally, the ammonium salt was used in arthritis and given intravenously Reactions were very severe and now the calcium salt is usually given by mouth. The usual dose is one tablet (0·5 grm) three times a day, and some authors reported good results with this

In 1937, Cohen treated a series of patients with doses ranging up to 6 grams per day and reported 71 per cent of improvement. Nearly a quarter of the patients had to be taken off the drug because of gastro intestinal upsets and vomiting.

Personal experience is that a large number of patients cannot tolerate the drug, but of those who can a proportion, somewhere about one in three, appear to derive benefit. *I have used it principally in*

een

the

to

muscle spasm

Prostigmine *is used in medicine chiefly to stimulate structures innervated by cholinergic nerves (stimulation of the parasympathetic system)* Its use in rheumatoid arthritis does not, however, involve *these actions though they appear* as undesirable side-effects during therapy

A brief consideration of these other actions is necessary before its use *in rheumatoid arthritis* can be properly assessed The possible actions on muscle tone can be conveniently divided into central and peripheral actions. Firstly, the possible action on synaptic transmission in the central nervous system. Sherrington introduced the conception of *central excitory* and *central inhibitory states* to explain certain phenomena relating to reflex action. This conception implied

Fig 100 Fig 101

Shows one knee only affected

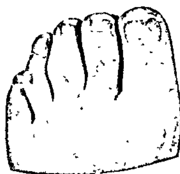


Fig 102

Rheumatoid arthritis of the feet
Note the swelling round the toes

that though the synaptic junction was bombarded by "all or none" impulses it was able by means of its previous level of activity to grade its responses both as to rate and intensity. This theory explains many complex reflex phenomena and is generally accepted. Fulton and Liddell maintained that the C.E.S. resulted from the liberation of a chemical substance at the synaptic junction, and that C.I.S. was due to the liberation of a different chemical substance. Acetylcholine was thought to be the substance responsible for the C.E.S., and indeed the application of this substance to the cerebral ventricles produces excitation of the neighbouring centres even though application to the cerebral cortex is negative.

It has also been reported that physostigmine applied to the cerebral or cerebellar cortex lowers the threshold of these areas to faradic stimulation; the drug also augmented certain spinal reflexes. Though this theory of the action of acetylcholine has been disputed, notably by Eccles (who supports the membrane hypothesis), the point at issue is that acetylcholine is far more likely to enhance the C.E.S. rather than the C.I.S.

Work on the chemical transmission of motor nerve impulses to voluntary muscle has produced the following points of relevance:

(1) Dale obtained evidence that acetylcholine is liberated at motor nerve end plates and serves as the transmitter of voluntary impulses to these muscles.

(2) The injection of a small dose of acetylcholine into the artery supplying the gastrocnemius muscle of the cat causes a sharp contraction of this muscle. If a minute quantity of this substance is applied to the motor nerve end plate of a muscle it produces a short tetanic contraction, ten times this quantity applied elsewhere on the muscle fibre has no effect.

(3) The intravenous administration of 0·2 mg/kg. of acetylcholine to a spinal cat caused an increase of 130 per cent. in tension of a gastrocnemious twitch induced by a standard stimulation to the motor nerve. Thus the laboratory evidence appears to be wholly against the conception that acetylcholine or physostigmine will relax muscle spasm.

Prostigmine is a synthetic alkaloid belonging to the physostigmine group of drugs. Its action is similar to that of physostigmine though of longer duration. Physostigmine by inactivating cholinesterase, which destroys acetylcholine in the body, has a qualitatively similar action to this latter drug.

Prostigmine was originally used for the relief of alleged muscle spasm in the modified Kenny treatment of anterior poliomyelitis. Kabat and Knapp then suggested that the drug should be used in rheumatoid arthritis for a similar purpose.

It should be noted at this point that prostigmine relieves the fatigue of skeletal muscle in myasthenia gravis, but aggravates the [illegible] Parkinson's Disease; these [illegible] neural junction, [illegible] gical knowledge.

Thus clinical and experimental work [illegible] at prostigmine

will produce hypertonus rather than hypotonus by its peripheral action.

The supporters of this drug suggest that the action must be central, this point has been considered earlier without any likely evidence being found, however, Kremer has recently reported a depression of spasticity and deep reflexes following the intrathecal injection of the drug into man

A further point is worthy of consideration. Owing to the high dosage of the drug employed, parasympathetic stimulation side-effects have been troublesome and in nearly all reported cases atropine has been administered simultaneously to counteract these actions The action of the belladonna group of drugs in the relief of the spastic symptoms of Parkinsonism is well known, and it is believed that this indicates that the drug has a primary depressant action on certain central motor mechanisms It is possible that a portion of the benefit reported from the use of prostigmine is due to the simultaneous use of atropine, and indeed it is claimed that atropine has some action on the muscular spasm in rheumatoid arthritis

Though some moderately enthusiastic clinical reports have been published, personal experience of this drug has not convinced me that it is of any great value Certainly further evidence both clinical and experimental is required before the drug can be regarded as having an established place in the therapy of rheumatoid arthritis.

Prostigmine may be administered orally or by injection. Absorption by the oral route is far from complete, and whereas the effective parenteral dose in man is from 0 5 to 2 0 mg , the oral dose may be 30 mg or more Consequently, both oral and parenteral routes are often employed simultaneously

mg prostigmine bromide with 5–15 minims (0 6–1 2 c c.) tincture of belladonna three times a day by mouth The dose of belladonna will show a wide range of individual variation.

The commonest toxic effects are dizziness, abdominal cramps, and precipitate bowel movements

Recent American work (Cohen, A , Tromer, P., and Goldman, J. (1946), *J A M A* , 130, 265), though not clarifying the theoretical issues, has provided clinical evidence of sufficient value to suggest that treatment with this group of drugs may be of considerable benefit in suitable cases These workers using physostigmine, largely on account of its relative cheapness, found that its therapeutic action was equivalent to prostigmine, whilst the side-effects were less marked

All medication was by injection, the dosage was 0 6–1 2 mg physostigmine with 0 4–0 6 mg atropine; injections were usually given daily in the initial stages, less often later The original paper should be consulted for details of cases treated

EXERCISES FOR THE ARTHRITIC PATIENT

The Hands

Start the exercises at the earliest possible moment but *do not fatigue* the muscles.

1. Alternately contract and relax the fingers, keeping a small rubber ball (like a squash ball) in the palm of the hand
2. Try pressing on the thenar eminence with each finger in turn
3. Stretch the fingers to their full length and press gently with their tips against any hard object.



FIG 103

A carpal cyst

The Arms and Forearms

Stretching the arm straight out in front, gradually flex elbow and wrist and fingers and raise the shoulder until the index finger is pressing vertically on the top of the head. Place the whole hand on the back of the neck. Repeat both sides several times morning and evening.



FIG 104

Rheumatoid arthritis of the wrist with a synovial protrusion X-ray changes (see Fig 105)



FIG 105

The wrist showing the synovial protrusion. The X-ray is shown in Fig 104.

Hips and Back

Keeping the thighs down with the bedclothes, lean forward and touch the toes, breathing out as you go forward Reverse the movement, breathing in until the body is flat on the bed

Lower Limbs

Lying flat, flex the hips and knees until the thighs touch the abdomen Reverse the movement until the legs are flat on the bed Abduct and adduct the thighs Repeat several times, inspiring as the lower limbs flex, and expiring as they return to the flat again

It is a great help to have a physiotherapist present to superintend the exercises

PROTEIN SHOCK AND ALLIED MEASURES

Protein "shock" or non-specific protein therapy has been used a good deal in recent years in the treatment of rheumatoid arthritis The usual technique is to use T A B vaccine, giving 50–100 million organisms intravenously The subsequent febrile reaction goes up to 105° and is accompanied by rigors and sweating and occasionally by delirium

Although this treatment undoubtedly has certain advantages in various syndromes, it can be said quite definitely that rheumatoid arthritis is not one of them It is no uncommon thing to find that this treatment was the starting-point of a downhill course which ended in complete crippling and occasionally leads to a condition of complete asthenia and helplessness

COLLOIDAL SULPHUR

A good many papers have been published on the use of this agent in arthritis

In 1927 Race was in favour of it after trying it on 42 cases at the Devonshire Hospital and in 1935 Rawls *et al* published a paper dealing with the treatment of 200 cases with an aqueous solution of colloidal sulphur containing 10 mgrm per c c given intramuscularly or intravenously twice a week The dose was increased to 20–30 mgm if necessary

After four months' treatment the average cystin content of the nails was increased from 10 07 mgm to 12 65 mgm but the sedimentation rate was only slightly reduced Some of the patients developed toxic symptoms such as headache nausea and diarrhœa Rawls says the normal cystin content of the nails is 12 mgm per 100 mgm of nail substance He found that of those patients who originally had a low cystin content 59 per cent improved after treatment, but of those patients whose cystin content was normal only 24 per cent improved He therefore considered that the cystin content of the nails should be estimated before treatment was begun

It was concluded that the cystin content of the nails was usually

normal in the younger patients and so sulphur was not useful, but in older patients the cystin was diminished and *sulphur was indicated.*

Various other preparations of sulphur have been used, such as a 1 per cent. solution of sulphur in oil, sometimes called "sulfosin."

Personal experience is confined to the aqueous solution of colloidal [illegible] Reactions were on occasion alarming, [illegible] is way, my view was that the treat- [illegible] experience of estimating the cystin *content of the nails, but a good paper on sulphur metabolism* in rheumatoid arthritis was published in 1934 (Salt and Neligan), and some salient facts are given in the section on ætiology.

For the reasons set down in these sections, it seems likely that there is some fault in sulphur metabolism in arthritis, but now we have to await some preparation of sulphur which is not so devastating in its effects before further progress can be made.

Iodine has been extensively studied in connection with rheumatoid arthritis, and iodine itself much prescribed.

It is probable that iodine owes its action in the body largely to its *effect on the thyroid. It is probably absorbed from the bowel,* in part at any rate, as di-iodotyrosine, and it has been tentatively suggested that tyrosin itself (apart from its specific dynamic action) may have some of the effects of iodine itself. Thyroxine is composed of 2 molecules of di-iodotyrosine

Mutch has suggested in addition that iodine is stored near inflammatory foci, and so it may have some effect on joints. A good prescription *is 5 minims of the French Tincture three times a day in* milk The urine should be tested periodically

A review of the metabolism of sulphur and iodine and their values in the treatment of arthritis has been published recently (Fletcher, 1939)

[illegible] and in large doses occasionally

[illegible] *a focus of sepsis* has been removed In this case a vaccine may usefully be given afterwards, [illegible] allowed to elapse.

[illegible] that streptococcal skin tests would [illegible] ossible usefulness of a vaccine, these

Vaccines may of course be either autogenous or stock, but it seems that the results do not differ *materially* Some *cases do well on* either, or poorly on both.

Warren Crowe (1932) has a stock vaccine made of many strains of *streptococci and two strains* of staphylococci. He uses this as a routine measure and has claimed great success with it.

Whatever vaccine is used the best results will be attained with [illegible] will avoid undesirable reaction [illegible] minimise the therapeutic effect It is not wise to increase the dose *if the patient is improving.*

BEE VENOM

May be given either by injection, by inunction with an ointment, or by using the actual bee itself

After an extensive trial of all these methods, the conclusion is reached that they are of little value Occasionally, it has seemed useful in myalgia

JAUNDICE

, be

has been linked with the improvement in arthritis said to occur in pregnancy

All workers are, however, not agreed and Hartfall, Garland and Goldie (1937) compared the results of gold treatment in 671 cases of rheumatoid arthritis of whom 74 had jaundice, with the hope of showing, if the assumption was correct, that the greatest improvement would occur in those patients who had jaundice

Their figures quoted below did not support the idea

RESULT OF GOLD TREATMENT OF PATIENTS WITH AND WITHOUT JAUNDICE COMPARED

Result	*Jaundice*	*No Jaundice*	*Total*
Cured	11 (7 5)	57 (60 5)	68
Marked improvement	37 (43 2)	355 (348 8)	392
Moderate improvement	7 (9 9)	83 (80 1)	90
Slight improvement	3 (4 7)	40 (38 3)	43
No improvement and worse	16 (8 6)	62 (69 4)	78
Total	74	597	671

(In brackets are the expected numbers—i e the numbers which should occur in each group if jaundice were in no way related to the result)

They concluded that the results in these cases which suffered from jaundice *were worse* than in those who did not It should be mentioned that the high proportion of jaundice cases in their series was due to sporadic outbreaks of infective hepatitis

Recently Gardner et al (1945) have published their results in the experimental transmission of jaundice to cases of rheumatoid arthritis

They commenced their experiments by using material from cases of infective hepatitis but found this to be unsatisfactory, and eventually used icterogenic serum With this they found that they were able to induce jaundice in a large proportion of the cases, and that the severity of the jaundice was no greater

By these combined means they produced jaundice in 32 of 312 patients inoculated In these patients the jaundice developed after an interval of 27 to 131 days They found no difference in the

arthritis between the day of inoculation and the day the jaundice appeared

Of the 32 patients successfully inoculated 10 showed complete remission and 8 considerable improvement. Of these 18, only one showed a sizable drop in the erythrocyte sedimentation rate after recovery from the jaundice, and this was from 60 mm per hour to 25 mm. per hour. Ten showed an actual increase

If the E.S R. can be regarded as any index of improvement, this is not very encouraging

In the cases which were improved, the clinical advantage was apparently very great, for cases previously in great pain and with great impairment of motion were restored to near-normal.

One cannot help being impressed with this improvement, even though it was temporary. These workers have shown in combination with Thor [illegible]
the factor [illegible]
an increase [illegible]

As the [illegible]
the plasma proteins, perhaps the retardation of the rate in the successful cases during the period of jaundice may be connected with such a change which is known to occur in infective hepatitis

More work will be required before any opinion can be expressed

My own experience with jaundice developing naturally in a patient suffering from rheumatoid arthritis is that it almost invariably produces a worsening in the arthritis, so that my experience coincides with that of Hartfall.

Nevertheless Gardner's work may be of the greatest use in the future, and the power of gold injections to produce a toxic jaundice has never been assessed.

It not infrequently happens that jaundice develops during gold therapy, and it is very often a matter of difficulty to decide whether it is of autohepatoxic origin The outcome in these cases is usually unfortunate

GOLD TREATMENT OF ARTHRITIS

The use of "chemotherapy," since Ehrlich first introduced arsenical preparations for the treatment of syphilis in 1890, has always been viewed with a certain amount of scepticism, except in the case of treatment of syphilis and certain tropical diseases, especially in this country. Attention was drawn to the possible use of gold by Robert Koch, and a great deal of unobtrusive work was performed during the first twenty years of the twentieth century, especially with regard to the use of salts of the metal in the treatment of tuberculosis.

During this period two names stand out, that of Feldt, working at the Robert Koch Institute in Berlin, and Mollgaard of Copenhagen. Feldt not only performed a vast amount of experimental work on the action of certain gold salts on a variety of organisms, but was also responsible, with his collaborators, for the chemical improvements which have done much to lower the toxicity of salts of the metal, while leaving their therapeutic value unabated. Mollgaard, in a

communication to the Danish Medical Society in October 1924, first described the therapeutic effects of the double thiosulphate of gold and sodium, named by him "sanocrysin" His book *Chemotherapy*



FIG 106

Case of rheumatoid arthritis at commencement of treatment



FIG 107

The same case two years later



FIG 108

The same case two years later Residual deformity minimal

in Tuberculosis followed this communication, and, as a result, the methods he advocated were extensively tried. Partly owing to general inexperience of the use of a notoriously difficult therapeutic agent, and partly owing to the marked toxicity of the earlier preparations, the method fell into considerable disrepute A large number of deaths were recorded and the medical profession generally was

somewhat naturally afraid to take the risks involved. Since the introduction, however, of the various organic salts of gold, largely due to the work of Feldt in Germany and Lumière in France, the question has been viewed somewhat differently, especially on the Continent The use of *gold salts* in phthisis is now accepted as of real value in selected cases

Among others, Feldt was impressed by the *possibility of* using these preparations of gold for [illegible] than that of Koch's bacillus, an [illegible] certain collaborators, notably Schiem [illegible] Heise, for a large number of animal experiments, whereby he showed that his new organic preparations of gold, especially those in which the gold was in direct combination with sulphur, could be used successfully for the eradication of streptococcal, spirochætal and other acute and chronic infections, artificially induced

Stimulated by these results, a number of clinical workers, especially in Germany, used salts of the metal in a large series of infections of varying ætiology As a result of these extensive experiments, it was early realised that chronic infective articular rheumatism responded to the treatment in a most promising manner. Among these workers, special mention must be made of Forestier, Coste Bourderon and Lacapere in France It was not, however, until February 1932 that particular attention was drawn in this country to the possibilities of this form of treatment, by an article in the *Lancet* written by Forestier The Hunterian Lecture of the Hunterian Society for 1934 was given by Forestier on this subject, and was reported in the *Lancet* (September 2, 1934) Study of the published results would suggest that gold constitutes a valuable addition to the pharmaceutical armamentarium employed in the treatment of so-called rheumatoid arthritis. The most suitable type of case for such treatment is discussed later. It is well known that removal of septic foci (teeth, tonsils, gall bladder, etc.) may bring about improvement in arthritic conditions, but that such improvement is frequently only temporary. It has therefore been insisted upon, by most writers, that elimination of any septic foci must be carried out as a preliminary to treatment. Physiotherapeutic methods, obviously palliative in their action, may be used concurrently and are in fact desirable.

Pharmacology of the Gold Salts

The pharmacology of the chemotherapeutic agents is still very imperfectly understood, in spite of the fact that a great deal of experimental work has been carried out on the subject. Whereas most of the early workers believed that gold salts must rely mainly on a direct bactericidal action for their efficacy, the passage of time has made it clear that such an explanation is far from convincing

Ehrlich in his researches on the organic arsenical preparations recognised two important principles, namely, that the compounds evolved should possess "parasitotropic powers to the maximum, while cellular toxicity was reduced to a minimum"; and secondly,

that they should stimulate the production of antibodies, which in their turn would act on invading organisms

Most of the early work on the subject was done from the point of

found that, *in vitro*, the salts have a mildly bactericidal action, but that, by using gradually increasing dilutions, bacteria will ultimately acquire an immunity to them.

If the gold does not act directly on invading organisms, it must in some way so affect the host that he is able to mobilise his powers of resistance more readily than heretofore It has been found that, after injection, the salts are dissolved in the blood plasma and eventually a certain proportion becomes fixed in numerous organs, The subject ferably more than the healthy subject The unfixed proportion of the gold injected (from 40–65 per cent) is eliminated mainly by the kidneys, to a lesser degree by the bowel and in very small quantities by the skin and lungs From a histological point of view, Feldt has shown that fixation takes place especially to the cells of the mesenchyma He states that the reticulo-endothelial system is specially affected and, as evidenc in the salts lympho performed on my own cases.

If this fixation to the reticulo-endothelial system is granted, Feldt's theory of catalysis appears to be possible He believes that a catalytic acceleration of the normal slow curative process takes place. This, he says, is due to what he terms "autolysis," by which term he describes the production of antibacterial substances as the result of tissue disintegration

A number of other theories have been propounded, for example, that of the production of "tissue shock" and the suggestion that gold may form a compound with the tissue proteins which is bactericidal be out by the fact that treatment of extremely debilitated individuals, whose resistance is low is practically useless

Method of Action

In 1941, Freyberg, Block and Levy showed that there was a retention of gold in the body during courses of injections As much as 80 per cent was said to be retained and the metal was found in the plasma and urine for six to twelve months afterwards For instance,

after an injection of 50 mg (of gold) the average plasma content was found to be 0·8 mg per 100 c.c and the amount excreted in the urine
week. The question
of injection.
the same or lesser
concentration than in the plasma The authors concluded that 25 mg of gold (or 50 mg of myocrysin) produced the maximum result

In 1942, the same authors concluded that gold absorption was complete from the sites of injection so far as the soluble inorganic salts were concerned The plasma values for colloidal gold sulphide are due to the fact that the colloidal particles are taken up by the reticulo-endothelial system The authors found that all the gold had left the blood within an hour, so cutting down the effective time during which it could exert its action

Both Freyberg's papers were reviewed in the *British Medical Journal* (December 20, 1941, and March 4, 1944), and good summaries appear there

Precautions

Before undertaking treatment, two requisites must be fulfilled, firstly a complete examination must be made and secondly the physician must be perfectly clear in his mind what complications he has to fear.

A complete clinical examination will naturally be necessary, with a full record of the joint condition. A routine search will be made for foci of sepsis. In addition, a complete blood count will be required, the estimation of the sedimentation rate and the result of the Wassermann test The urine should be examined chemically and bacteriologically Routine X-rays should be taken.

Contra-indications are renal, hepatic, or blood disease.

Some authorities recommend that a phase of physical treatment should be instituted first, and that gold should not be started till the effect of this has been noted. There seems little point, however,

Methods of Dosage

From the point of view of gold dosage, cases of arthritis can be divided into three groups (Fletcher, 1944).

(a) Those entirely resistant to gold.
(b) Those who respond only when the dosage is raised to the ceiling level of 50 mgm of a crystalline salt weekly.
(c) Those who respond to gold in the very smallest doses (5 mgm. weekly)

So far, no method is known by which these different types can be separated in advance. In both the very severe cases and mild cases,

I now start with 5 mgm. weekly, and I continue at that dose until either no improvement takes place, or improvement ceases. (Most preparations market 10 mgm as their lowest dose. Half of one of these ampoules is a convenient method to arrange the dose The other half has to be discarded.)

The dose is then increased to 10 mgm and kept at that dose in the same way. The dose is only further increased when further improvement is not taking place, and the ceiling dose is 50 mgm of the salt weekly Myocrysin (May and Baker) is used as it seems that one comes to understand one particular preparation.

Although the figures have not been statistically corroborated, about 25 per cent of cases are entirely resistant to gold. Of the

is satisfactorily reduced

After the course of, say, 1 gram is completed, 5 mgm is continued once a fortnight for as long as six months

Types of Gold Preparations

Myocrysin is an aqueous solution of sodium aurothiomalate It contains 50 per cent of gold (May and Baker)

Solgahol B.—The oily preparation is generally used It is aurothioglucose and contains 50 per cent of gold This is absorbed slowly and gives plasma values equivalent to two-thirds of those obtained with aqueous solutions

Calcium aurothiomalate is also absorbed slowly, but the American Rheumatism Association agreed that it was less toxic I have used it for about two years and, although toxic complications are minimised, I am not convinced that it is so effective It contains 50 per cent of gold

Colloidal gold salts are not recommended for reasons already stated

Prophylaxis of Toxic Reactions

Wilson (1937) has shown that by adding calcium glucono-galacto-gluconate to his injections of sanocrysin he was able to reduce the incidence of toxic reactions from 48 per cent to 15 per cent He used his injections in cases of pulmonary tuberculosis and went up to very large doses, as much as 5 5 grm of the salt being used in a course

So far as arthritis is concerned, the general opinion seems to be that the addition of the calcium salts to the gold tends to minimise reactions

Value of Blood Counts as a Prophylactic Measure

The following summary is based on a close analysis by Crosby (1936)

The chief points which arise are

TABLE SHOWING CHANGES IN BLOOD PICTURES OCCURRING DURING TREATMENT
(EXCLUSIVE OF SEDIMENTATION RATE ESTIMATIONS)

Case No	Hæmoglobin			Total Red Cells			Leucocyte Count Total Count			Leucocyte Count Lymphocytes			Leucocyte Count Monocytes			Leucocyte Count Eosinophils		
	Before Treatment	During Treatment	After Treatment	Before Treatment	During Treatment	After Treatment	Before Treatment	During Treatment	After Treatment	Before Treatment	During Treatment	After Treatment	Before Treatment	During Treatment	After Treatment	Before Treatment	During Treatment	After Treatment
	%	%	%							%	%	%	%	%	%	%	%	%
1	68	65	80	4,120,000	4,480,000	5,150,000	7,100	10,000	11,600	38	36	24	3	1	4	2	21, 14, 1, 10	1
2	95		92	5,180,000		4,590,000	6,200	.	7,400	29	.	28	15		3 5	1		0
3	82	.	100	4,270,000		5,100,000	6,600	.	8,200	28	.	36	4		3	1		0
4	90	82	88	5,590,000	4,700,000	4,680,000	10,400	10,000	4,800	25		27	4	3	3	2	6	2
5	80	88	102	4,060,000	4,875,000	6,060,000	9,000	8,200	6,000	35	23	30	1 5	8	5	2	4	3
6	90	76	90	4,680,000	3,970,000	4,740,000	7,200	7,600	8,800	27	27	18	0	5	1	0	4	4
7	.	100	100	.	5,400,000	4,900,000		7,000	7,500		30	?		3	?		4	?
8	85	94	104	5,250,000	5,000,000	5,770,000	6,000	8,600	5,400	33	29	23	2	3	2	0	3	0
9	98	.	94	5,010,000		?	12,000		6,400	20 6		33	6 6	. .	6	2 8	.	1
10	70	86	85	4,442,000	4,360,000	4,500,000	9,400	7,600	5,200	26	29	30	2	8	9	0	6	3
11	85	.	98	4,410,000	.	5,120,000	3 800	.	10,000	30	. .	18	4	. .	5	0	. .	2
12	80	. .	100	4,100,000	. .	4,950,000	9,600	. .	7,300	11	. .	34	2	.	0	0	.	6
13	?	90	90	5,360,000	. .	4,710,000	7,400	. .	4,000	?	34	30	0	. .	0	0	. .	0
14	80	85	100	4,999,000	4,900,000	5,260,000	10,400	11,000	12,800	7 5	28	20	2	2	1	·5	1	1
15		84	86	. .	4,330,000	5,550,000		10,400	6,400	. .	20	21	. .	0	2	. .	0	0
16	80	. .	100	3,800,000	. .	4,530,000	4,400	. .	5,000	20	. .	27	10	. .	10	0	. .	0
17	60	70	84	4,450,000	4,850,000	5,100,000	10,600	8,800	12,600	42	29	37	0	7	2	2	0	0
18	.	. .	.	. .	. .	. .	. .	. .	. .	. .	. .	.	. .	. .	. .	. .	. .	. .
19	92	80	95	4,800,000	4,700,000	4,920,000	5,400	6,400	5,900	20	35	31	1	2	3	6	0	3
20	83	105	112	4,500,000	5,500,000	6,330,000	7,400	5,000	8,800	50	25	33	3	0	3	6	5	2
21	92	98	104	5,560,000	5,650,000	5,210,000	12,000	5,400	9,200	45	48	. .	2	0	. .	2	1	
22	87	. .	94	4,750,000	. .	4,500,000	5,200	.	9,800	34	. .	20	2	.	7	3	. .	5
23	82	.	102	5,000,000	. .	5 360,000	4,600	. .	6,400	31	. .	29	7	. .	3½	4	. .	1
24	75	. .	82	4,000,000	. .	4,250,000	6,000	.	5,200	36	.	34	2	. .	6	0	. .	2
25	80	. .	98	4,800,000	. .	5,000,000	?	. .	9,760	?	. .	19	?	.	6	?	. .	15

(1) It seems that a secondary anæmia is not so common as is usually thought; Shackle holds the same opinion

(2) The red-cell counts were not materially altered

(3) The total leucocyte count was not helpful

(4) The differential count showed a degree of relative lymphocytosis. A relative neutropenia is uncommon.

(5) Occasionally a striking eosinophilia occurs One case showed no sign of either biotropic or toxic reaction, and another showed an erythema of an eczematous type.

(6) Serial blood counts give the first indication of impending complications

Toxic Manifestations of Gold Therapy

There is no doubt that toxic manifestations are not so common to-day as they used to be ten years ago and this is largely due to the fact that the doses used are very much smaller. Nevertheless, they are still formidable when they do occur

Crosby (1936)[1] investigated the question of toxic reactions in my clinic at Queen Mary's Hospital for the East End He found the incidence to be high He mentions that certain reactions are said to be due to a phenomenon known as "biotropism" The term is used to describe what is believed to be an increase in the virulence of "latent organisms" excited by such agents as X-rays, gold, arsenic, or bismuth Apparently [illegible]
to the toxicity of the g[illegible]

[illegible] this list but
[illegible] due to the
toxicity of the gold itself The rôle of allergy in this matter is unsettled It is claimed that the "biotropic" reactions are not an indication to stop treatment, but it is difficult to believe that this can be true

Hinault and Mollard (1934) describe a method of separating the biotropic and toxic states. They use 0 2 c cm of a gold salt (crisalbine) intradermally A positive reaction occurs in the toxic conditions but not in the biotropic cases

Immediate reactions consist of general malaise and giddiness. Crosby noticed them in one-third of his cases, and included nausea, vomiting and diarrhœa as occurring occasionally

Severe immediate reactions such as pallor, shock, pulmonary and laryngeal œdema are described but must be very uncommon I have never seen them

Focal reactions —One-third of Crosby's patients complained of an exacerbation of their pain This is not a serious matter and soon passes off It generally occurs after four or five injections A *degree of pyrexia* occurs occasionally and may herald the onset of agranulocytosis or of a dermatitis

Gastro-intestinal and hepatic reactions occur occasionally, and a

[1] The University of Cambridge awarded an M D. degree for this work

history of previous upsets of this sort is discouraging if gold therapy is being considered. *Jaundice* is an indication of hepatic insufficiency. *Fatal icterus gravis* has been recorded and even *acute yellow atrophy.* There is no doubt that diarrhœa may occasionally follow an injection.

Toxic nephritis has been recorded, and it is usual to examine the urine before each injection. A slight degree of albuminuria, however, is not uncommon and is not as a rule a contra-indication to further treatment.

Skin lesions are the commonest form of toxic reaction. Pruritus occurs early and in my experience is always an indication to suspend treatment temporarily. If *skin lesions can be seen,* treatment should be interrupted immediately and not commenced again for some weeks An *exfoliative dermatitis* is a very serious complication and needs bed

mouth.

Blood Conditions

Hæmorrhagic thrombocytopenic purpura is reported, the usual agents being gold and arsenic (Hudson, 1935) *Agranulocytosis* is sometimes superadded.

Naturally, these reactions are extremely serious and the best prophylactic measures are serial blood counts.

Gasking (1938) is of opinion that serial platelet counts are of value in foretelling serious toxic blood conditions in gold therapy. He found that there was a considerable fall in the number of platelets immediately after the gold injections This usually lasted three days He suggested that platelet counts should be done before the injections were started to get a base line, and then repeated before each injection. In addition, it was helpful to repeat the count three days after the initial injection so as to note the fall, if any

The reliance which can be placed on blood examinations as a whole and the eosinophil count in particular is discussed below.

Other possible blood dyscrasias are *aplastic anæmia* and *malignant thrombocytopenia.*

Treatment of Toxic Reactions

The injections are stopped immediately. *It is usual to give liver by mouth,* a quarter *of a pound or more three times a week* Liver extract may be used. Some

sug scribe 5

tab rwards.

POST-MORTEM FINDINGS

A case of gold dermatitis was admitted to hospital in February 1944. In May 1943 the patient, a woman aged 47, had developed



Fig 109

Exfoliative dermatitis of the hands After treatment with gold



Fig 110

Gold dermatitis The appearance is somewhat obliterated by the remains of "Siccolam on the face

rheumatoid arthritis with ...
of 103 mn
1943 she h
developed a morbilliform rash on the inner aspect of the thighs and a mild stomatitis The only abnormality in the blood count was a mild leucopenia of 5,900 per c.mm with 65 per cent. polymorphonuclear leucocytes. There was no albumin in the urine. The skin rash began to fade, but a further dose of gold was administered and the rash came back. It gradually became generalised and in February 1944 she was admitted with an exfoliative dermatitis.

She was treated with sodi -bicarb. baths, siccolam locally, 5 c.c. calcium thiosulphate intravenously each day, and 2 c.c anahæmin



FIG 111

Exfoliative dermatitis of the feet.

intramuscularly twice a week Intravenous glucose (5 per cent) and saline as a drip (Dr. Sadique).

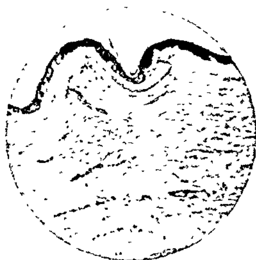
The skin appeared to clear but on the 26th the temperature rose to 102° and she became dyspnœic, and on the 27th she died.

Report on material from a case of Gold Dermatitis by Miss Lucy Wills and Dr. M. Lowenberg

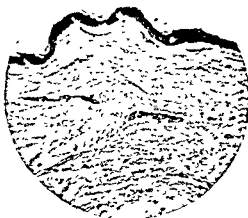
... that the ... re was a marked increase in pelvic fat and the pattern was practically obliterated. Microscopically extreme congestion with hæmorrhage into the kidney substance The tubular epithelium is swollen and largely shed into the lumen of the tubes; number of glomeruli reduced and the surviving ones very cellular, many with hæmorrhages in the tufts Blood vessels thickened *Conclusion*, acute toxic nephritis in a kidney showing changes of chronic glomerular nephritis

Lung.—Acute hæmorrhagic bronchopneumonia.

Liver cells swollen. Central necrosis of lobules; pigment deposited in cells



A



B

FIG 112

Sections through the skin Note that changes are less than would be expected from clinical condition This was because the dermatitis was clearing up at the time of death

Sections show an œdematous, thin horny layer with scaling in some areas. The stratum granulosum is poorly developed, the rete pegs being either small or absent

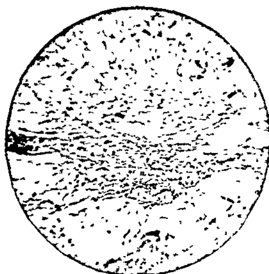


FIG 113



FIG 114

FIGS 113 and 114

Sections through the skin The corium is œdematous, the collagen bundles are broad but their fine fibrillary structure is preserved The vessels are increased in number and congested A few show perivascular infiltration (Fig 114) Hair and sebaceous glands are missing and the sweat glands atrophic (Fig 112B).
In the subcutaneous fat the connective tissue septa are broadened (Fig. 113).
No pigment demonstrated

kidney failure or from bronchial pneumonia. The appearances in the lung suggest an acute terminal infection.

Miss Lucy Wills, who carried out the pathological work, was of opinion that the likely cause of death was kidney failure.

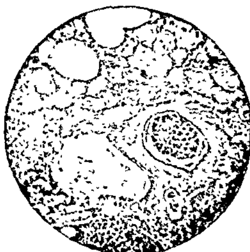


FIG 115

Gold dermatitis Section through the lung showing hæmorrhagic bronchopneumonia

The case is quoted in full here because comparatively little post-mortem material has been published and because it shows well the point that a patient may appear to be recovering from some toxic accident, when quite suddenly a relapse occurs In addition it shows the danger of giving even one injection of gold to a patient who is suffering from toxic manifestations These toxic reactions may be delayed as much as three months after the last injection is given.

It is always as well to remember that gold salts are a valuable weapon to combat the acute constitutional stage of rheumatoid arthritis They are quite useless for the static, ankylosed, deformed stage, and are never useful at any stage in osteoarthritis or fibrositis.

THE USE OF BISMUTH AND ITS SALTS

In 1944, Douthwaite published the result of treating twelve patients with intramuscular injections of bismuth or bismuth salicylate He chose bismuth because it acts like a heavy metal and is not so toxic as gold He used either 1 mil of bismuth or 2 mils of bismuth salicylate, each containing 0 2 g of bismuth or bismuth salicylate respectively His course was 10 injections equivalent to a course dose of 2 g He concluded that bismuth was capable of

exerting a beneficial influence on arthritis, but that it was inferior to gold.

It has always seemed that bismuth was one of the drugs which should be tried in arthritis, and in 1937 a small series of cases were treated with it in my clinic. My conclusions (not published) were much the same as Douthwaite's, but I have only used it occasionally since

Sodium Bismuth Tartrate

In a letter to the *Lancet* of February 19, 1944, Hall says that he tried sodium bismuth tartrate on the arthritis of natives on the Gold Coast some years ago. He was impressed with the result and has used it in various types of locomotor disorder, but thinks it is best for rheumatoid arthritis The drug is used in aqueous solution isotonic with glucose and preserved in autoclaved rubber-capped bottles. The strength is 1 grain to 1 c c and is given deeply into the muscles.

This treatment has been used a good deal in London. My experience is that the injections are painful and there seems no way of minimising this I have never seen any toxic reactions (the injections are never given more than once a fortnight and often only once a month), but at the moment it is difficult to be certain that any good comes of it.

Chaulmoogra Oil

Is of no value in rheumatoid arthritis

Sodium Glycerophosphate

Daily intravenous injections of 10 c.c. of a solution containing 2·5 g of glycerophosphate in distilled water were recommended by certain Italian physicians One, Rinaldi, a physician of Tuscany, built an enormous local reputation on an injection which the Italian Home Office published after his death and was said to contain sodium glycerophosphate. This was used for some months in my clinic in selected cases There is no doubt that the injection leads temporarily to a feeling of great good health. Shortly after the injection a feeling of warmth is felt all over the body, and the patient sometimes becomes euphoric. Injections were given daily for a fortnight, but apart from the tonic effect it never appeared to affect the joints or the sedimentation rate.

[illegible] bismuth

Occ [illegible]

per [illegible]

DEEP X-RAY TREATMENT

This is a method of treatment which has been used spasmodically for years. So far as rheumatoid arthritis of peripheral joints is concerned, results differ tremendously in different cases. Occasionally one is left with *one joint* (generally a knee or an ankle) which is extremely painful while the other joints have cleared. On occasion,

one or two doses of deep X ray to this one joint has relieved the condition to an appreciable extent On the other hand, I have seen cases in which deep X-ray treatment has been used somewhat indiscriminately, and has resulted in undoubtedly worsening the condition of the patient and of his arthritis

All treatment of this sort should be carried out in close conjunction with an X-ray therapist of experience and reputation

INJECTIONS INTO JOINTS

The injection into joints of substances intended either to relieve pain or to increase movement has been practised sporadically for many years In 1928 Payr write a long treatise on the subject For this purpose, he divided his joints into those with effusions and those of the dry contracting adhesive type His treatment consisted of a very complete anæsthetisation of the joint, and injection of pepsin-Pregl solution to dissolve fibrin clots, if present In the wet type he then injected, after withdrawal of the effusion, the following solution

Ac carbol liqlf puriss, 30, camphoræ tritæ japon, 60, alcohol absolutissimi, 10

1 c c of this was used and then the extremity was placed on a splint and compressed with sorbo sponge He also used the *pepsin-Pregl solution* for infiltrating the capsule if it was thickened and painful, but he does mention that a dormant infection may occasionally flare up

He condemns Jodipin, an iodine compound recommended by other authors

He says that the untoward symptoms sometimes recorded after the injection of camphorated phenol are entirely due to the substance being injected into the blood stream If the injections fail he goes on to synovectomy or arthrodesis

In 1938 Laughton Scott described a *gomenol preparation* for injection into joints with the following formula camphor, 5 g, gomenol 20 g, ether, 2 g, olive oil ad 100 g This is injected after sterilisation into painful joints Sometimes it seems to relieve pain and enhance mobility

Acid potassium phosphate —An article recently appeared (*Lancet*, 1944 1 563) advocating the use of this substance for joint injection

My experience so far has been confined to osteoarthritis of the hips, and I have not been successful in alleviating the condition by this method so far

Recently Waugh has published his work on the injection of joints with a solution of 0 2 per cent lactic acid with 2 per cent procain This is made by Brady & Martin Ltd, Newcastle upon Tyne It *certainly appears to relieve certain cases of arthritis, and is even* beneficial in cases of osteoarthritis of the hips

Novocaine is occasionally used by itself and in the case of joints which are extremely painful it may relieve the pain for a very considerable period ½ per cent solution is usually strong enough and a knee joint will take about 10 c c

Manipulation of Joints

Many authorities warn against the manipulation of joints in rheumatoid arthritis This is a mistake The warning should be against manipulation by one who is not well trained and experienced in such manœuvres. Little harm comes from manipulation provided it is done slowly and very gently and provided too much is not done at one time.

In the very acute stage no indication arises for manipulation as the whole problem is the *prevention of deformity*. In the more chronic stage with normal pulse and temperature, but still with considerable pain and a raised sedimentation rate, skilful manipulation may be a most valuable help.

Manipulation should not be ruled out because the patient is still in the active stage of disease

Manipulation of the fingers, however, has special difficulties. If it is to be attempted at all, only one finger should be done at a time and long pauses should intervene between manipulations. This is essentially a matter for the expert and more harm than good may easily be done

PLASTER SPLINTS AND CASTS

The use of plaster splints and supports are a very necessary part of the treatment of arthritis, and the physician wishing to specialise in locomotor disorders must go to the trouble of using plaster, and understanding its possibilities

The proper application of plaster moulds and plaster splints has four main objects·

1 The relief of pain
2. The relaxation of muscle spasm.
3 The reduction of swelling.
4. The prevention of deformity.

The joints which more usually require plaster are the *hand and wrist*, the *knee* and occasionally the *elbow* and *ankle*.

Hand and Wrist —The best and easiest way to do this is to make a plaster slab This can be done by soaking a plaster bandage in warm water for a very short time and rolling it backwards and forwards on a suitable table until a slab of the desired size is made

This should be about 18 inches by 9 inches. The patient is then asked to lay the pronated hand and forearm on the slab, which is cut to allow the thumb to come through The slab is moulded round the limb until it is set and the redundant portion of the plaster cut away. It is then allowed to dry and polished with plaster. It is important to have the wrist turned to the radial side to compensate for any possible ulnar deviation

The slab can then be either bandaged on or held on by rubber bands or webbing.

The knee joint.—With the patient lying prone a thin layer of vaseline is applied to the back of the thigh, knee and leg Wet

plaster bandages are then rolled backwards and forwards over the back of the limb gradually descending as the required thickness is obtained. This is allowed to dry and polished in the usual way.

If the *ankle joint* is to be included it is as well to let the foot dangle over the edge of the couch and to go down as far as the plantar aspect of the foot. In this way the ankle will be included at about the correct angle.

An *alternative method* is to use a plaster cast. In this case, stockinet should be applied round the limb first and made quite smooth. The plaster bandages are applied over this, but care should be taken not to pull the bandages tight. Each layer should be laid on the top gently but firmly

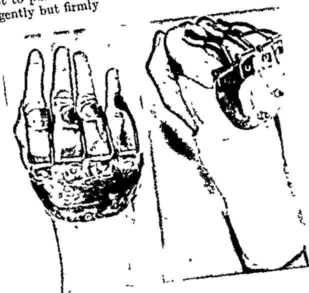


Fig 116

Bodenham's Splint (see p 282)

... the type of work are usually bivalved, i.e. they are ... f the limb with saw and shears ... through

its full range of movement.

It is unwise to leave joints affected by ... Adhesions may form ... immobilised for more than two or three days ... with great rapidity and a full range of movement should be aimed a... either every day or every other day

In cases where the extensive or extended use of plaster is anticipated, or where it seems likely that ankylosis will supervene, the help of a... orthopædic surgeon should be enlisted. It is neither fair to him or ... the patient to wait until matters are far advanced before doing so

Splint to correct ulnar deviation.—Ulnar deviation is an unsight... deformity which adds considerably to the distress of arthri...

patients Bodenham (1943) has devised a simple splint which aids in its correction. The accompanying illustration gives an idea of its construction.

The deviation is principally due to œdema and weakness of the capsules of the metacarpophalangeal joints, allowing unfettered movement On this base the effect of gravity tends to produce the deformity The early step in treatment is the use of plaster splints, but if these have not been used Bodenham's splint may be effective in the later stages A half-arm plaster splint is applied and the screws of the apparatus are embedded in it. The effect of the finger pieces is towards radial deviation, and the patient is able to exercise his muscles in the correct position.

Physical Therapy

Almost the whole range may have to be used at one time or another, but two measures are of outstanding importance.

General superficial massage is of the greatest help to these patients and seems to exercise a very beneficial effect. Although many people have suggested that circulatory disorders are an important factor in arthritis, no one so far has been able to prove it. It may be that massage achieves its effect by relieving some part of this difficulty.

Ultra-violet light has been condemned because it is said that pigmentation may occur in the skin if gold is given at the same time. If general carbon-arc is used there is, in my experience, little danger of this I have used it for many years in conjunction with gold, and found it most helpful and satisfactory.

Other measures are discussed in the chapter on Physical Therapy, but there is no doubt that heat, generally applied from the radiant heat and infra-red lamps, is a measure which relieves pain, and to some extent muscle spasm, and will be necessary at some stage in nearly every case of arthritis

The Surgery of Arthritis

Surgery can be of the greatest possible help in arthritis

Multiple arthrotomy and lavage—Timbrell Fisher (1937) suggested the advisability of arthrotomy and lavage, and in 1938 Savage published the results of one of his cases The operation may be combined with a *partial synovectomy*.

It appears that good results may be obtained from a simple lavage of the joint

In Savage's case, both knees and both elbows were so treated at three sittings and good results were reported

Probably the joints which respond best are those which are the seat of a hyperplastic synovitis

Drilling of the femoral head—It was found that in a case of [illegible] fracture

nent

f the

Kersley (1938), although unconvinced of the reasoning behind the procedure, decided it should be given a trial He used local anæsthesia and so only explored the hands and wrists, elbows, knees and feet. He thought osteoarthritis benefited to some extent from this procedure, but in gout and rheumatoid arthritis was unconvinced

Other Surgical Procedure

Other operative procedures include synovectomy (a very useful operation for very painful knees), arthroplasty, arthrodesis, and various plastic operations

They have special indications.

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CHAPTER XVII

VARIANTS OF RHEUMATOID SYNDROME

I. *STILL'S DISEASE*

THIS is generally regarded now as the rheumatoid arthritis of children, but it has certain features which are unlike rheuma-

rare It affects girls rather more than boys and is usually seen between the ages of three and six. The youngest recorded case was fifteen months old. The inflammatory changes differ from rheumatoid arthritis in that they are more periarticular than articular in distribution; the muscles and ligaments bear the brunt of the attack *in the first place* It may be mistaken for rheumatic fever in its early phases and occasionally a past history of rheumatic fever is obtained.

The disease may start with fever and swelling of joints and the course may be a rapid one More often the onset is insidious with a prolonged *prodromal period, the swelling of the joints follows* In these cases there will usually be periods of activity and quiescence. The knees seem to be the joints attacked first, wrists, elbows, fingers and ankles follow generally in that order. The joints are usually involved symmetrically, and the wasting of the periarticular tissues gives a characteristic fusiform appearance The cervical spine is sometimes involved early. Pain may be present but is not a prominent symptom. In many cases the swelling of the spleen and lymphatic glands is a fairly early sign Occasionally the enlargement of the epitrochlear gland is of diagnostic help. The glands are not tender

Tonsillectomy in the early stages may improve the prospect, but does not lead to permanent remissions. Subcutaneous nodules *sometimes occur round the elbows and the ulna bone* Ankylosis is usually fibrous and not bony. Premature ossification of the epiphyses with dwarfism is said to occur The X-rays show osteoporosis and loss of joint space when the cartilage is involved. The sedimentation rate and the white-cell count are both raised *during the active stage.*

Morbid anatomy findings include enlargement of all lymphatic glands, amyloid degeneration of the spleen and liver, pleurisy and pericarditis, and in cases where albuminuria has been a feature,

classed their case under secondary amyloidosis. Still showed that an unsuspected pericarditis with an adhesive mediastinitis was present *at autopsy.*

Treatment

Focal sepsis is searched for and removed where found These cases should be nursed in sanatoria and if possible in the open air Gold injections are useful provided the dose is kept low The top dose should be 20 mgrm weekly for a child of five years, and the bottom 5 mgrm Physiotherapy is extremely useful and the help of the orthopædic surgeon may be required

II. ARTHRITIS MUTILANS

Under the name of "main en lorgnette," Pierre Marie in 1913, and Wergeldt in 1929, described a very severe form of arthritis with unusual features In Wergeldt's case, the first phalanges of a woman 64 years old had almost completely disappeared The middle phalanges were largely absorbed, and the terminal phalanges atrophic The disappearance of the bones produced ring-like folds or invagination of the skin of the fingers which resembled a folded telescope, this suggested the name "main en lorgnette" In Pierre Marie's case, fatty degeneration of muscles and other tissues was found with replacement by granulation tissue In 1935, Stursberg published two cases which he assigned to this category but in his cases the spine was involved as well He described complete ankylosis of the spine, which makes one wonder whether these were really cases of ankylosing spondylitis with involvement of peripheral joints In one of his cases the destruction of bone involved the feet Another author (Wassing, 1936) described a case in which the metatarsals alone were involved all the other joints being entirely normal The metatarsal destruction and the ring-like invagination of the skin were as described by Pierre Marie in the hands This case, however was in a woman aged 24, while Stursberg's cases were in women aged 53 and 45 respectively



Fig 117

Arthritis mutilans

Showing the invagination of the skin where the joint has almost disappeared

So far as ætiology is concerned, it has been suggested that the condition may be familial or, in view of its occasional appearance at the menopause, that it has endocrine or metabolic ætiology

Rheumatoid Arthritis in Adults associated with Splenomegaly

This is a condition which was first described by Chauffard in 1896 and Herringham in 1909, and is associated with enlargement of the

lymphatic glands Since that time the syndrome has been reported a number of times with varying interpretations. In certain cases additional features have been noticed.

III. FELTY'S SYNDROME

This was first reported in 1924, and consists of rheumatoid *arthritis*, splenomegaly, leucopenia, marked loss of weight, and a yellowish-brown pigmentation of the skin. The age incidence varies but affects middle-aged men and women chiefly. The syndrome is characterised by periods of remittent pyrexia The splenic enlargement may be massive and is accompanied by a slight increase in the size of the liver and generalised enlargement of the lymphatic glands The leucopenia ranges from 4,000 cells per c.mm to 1,000 The differential count is roughly normal and the red cell is reduced, but not in proportion to the leucocytes This syndrome has been a puzzle to students of arthritis and in 1942 Talkov *et al.* investigated it. They agreed that rheumatoid arthritis could be accompanied by splenomegaly and leucopenia, and suggested that if this occurred this should be its title. They did not agree that a special syndrome should be made of it and were of the opinion that many of the cases reported as Felty's syndrome were examples of splenomegaly and leucopenia due to other causes In spite of this the syndrome has interest, and two well-documented cases were reported by Collins in 1937 His two patients had rheumatoid arthritis of differing severity, with enlargement of the liver and spleen and a neutrophil leucopenia One patient had lost weight but the other was obese. There was no mention of pigmentation He noted that 90 per cent. of the polymorphs possessed single undivided but complex nuclei, and considered this might be due to destruction of the more mature cells Some think it is a blood dyscrasia with arrest in the maturation of the polymorphonuclear leucocytes. Injections of pentonucleotide produced no increase in the polymorph count and Collins assumed there might be a deficiency of bone marrow function. He went to great pains to exclude other causes of hepato-splenomegaly, and was satisfied that the neutropenia was not due to the use of amidopyrin. In the course of his work blood counts were done on 472 new patients suffering from rheumatism. Only one had a white-cell count below 4,500 per c mm and that patient had an associated pernicious anæmia. He reckons the incidence of severe neutropenia in rheumatoid arthritis at less than 0 5 per cent No doubt some of the syndromes associated with splenomegaly and leucopenia have arthritis as one of their complications, and it is inadvisable and may be premature to add another named syndrome to the triad of arthritis, splenomegaly and leucopenia. It, therefore, seems reasonable to take the view that this triad may occur, but that it is not likely to represent another additional disease. It is certainly rare. A good many years ago, splenectomy was advised for this syndrome Such a procedure could hardly be justified in the present state of our knowledge. The platelet count is usually normal

IV. PSORIATIC ARTHROPATHY

Psoriasis and rheumatoid arthritis are two conditions which are

With rheumatoid arthritis (254 cases)—8 times 3 1 per cent
With osteoarthritis (253 cases)—twice 0 78 per cent
With osteoarthritis of the hips (44 cases)—once 2 2 per cent
With myalgia (114 cases)—twice. 1 7 per cent

Barber (1941) stated that arthropathia psoriasis dates from the time of Alibert (1822) and that Bazin (1860) made a distinction between psoriasis arthritica and psoriasis herpetica Barber's letter quotes all the authorities, including Garrod and Evans (1924), who stressed the frequency of synovial effusions Of the patients who suffer from psoriasis about one per cent also have arthritis One author (Epstein, 1939) described 22 cases, the skin lesion appeared at an average of 6 6 years before the joints were affected Bauer *et al* (1941) found that 23 out of 26 cases of psoriasis with arthritis suffered from the rheumatoid type The only peculiarity seems to be that when psoriasis severely attacks the nails, the *terminal joints* seem to be frequently involved, and especially those of the foot Some authors have described changes similar to those described under arthritis mutilans

It is difficult to be certain that the changes produced in the psoriatic arthropathy are any different from those seen in an ordinary case of arthritis The blood sedimentation rate may be raised in psoriasis and not a great deal of dependence can be placed on it The involvement of the terminal joints of the toes is the most important piece of evidence, as these joints are never involved in rheumatoid arthritis

V. REITER'S DISEASE

During the war, mostly in the Middle East, an unusual form of arthritis has appeared It is associated with urethritis and conjunctivitis The urethritis usually appears first and may be of an acute or chronic type It is usually sterile, and gonococci are never found The eye symptoms appear next and lastly the arthritis Some authors (Kruspe, 1941) have considered that there is some connection with dysentery

The condition clears up entirely on symptomatic treatment Very occasionally a sterile urethritis may be associated with ankylosing spondylitis *A recent article gives a good account* (Vallee, B L. (1946), *Arch Int. Med*, **77**, 295)

VI. TUBERCULOUS RHEUMATISM

Certain papers, mostly by French authors, have been written on the subject of tuberculous rheumatism Some cases of infective arthritis also suffer from pulmonary tuberculosis and this section sets

The Present Series

A number of cases were noticed of frank pulmonary tuberculosis attending hospital with a chronic polyarthritis indistinguishable from rheumatoid arthritis. After a study of the literature it seemed that an impasse had been reached on this subject and that some different method of approach would be necessary. Timbrell Fisher (1929) had advocated arthrotomy and lavage in the case of joints where recurrent pain and effusion were disabling features This treatment was adopted and a biopsy was made of the articular cartilage and synovial membrane. Dr G S Wilson, Professor of Bacteriology and Immunology in the University of London, was approached, and asked to co-operate in the examination of the specimens taken at biopsy. He agreed to do so, and the first specimen was taken in October 1937 Details of the cases up to the time the biopsy was made are appended Only five cases are quoted, as these were examined *in extenso* by Professor Wilson The sixth case was examined by culture only.

Case I

R T Female Age 48 Housewife

A case of rheumatoid arthritis with a three years' history of pain in the left shoulder Gradually the pain had spread down to her hands and, four months before admission, to her hips and knees The hands and knees were swollen

Five years before admission she had been treated for pleurisy and pulmonary tuberculosis in a sanatorium for eighteen months Shortly after this, she had developed a fibrous stricture of the pharynx Her father had died of pulmonary tuberculosis

On admission, both hands and wrists were swollen and tender In addition, there was swelling of both knees, with effusion There was considerable loss of weight, which at that time was 7 st 4 lb. The chest showed impaired movement on the right side with an impaired percussion note and crepitations at the apex

The X-ray confirmed an infiltration at the right apex

Temperature showed an evening rise to 99 6° F Sputum was negative

Investigations

Blood sedimentation rate—18 mm at the hour White blood cells—7,100 with normal distribution Mantoux test with O.T was positive at 48 hours (erythema and œdema).

Case II

T L Male Age 61. Stonemason

A case of rheumatoid arthritis, of four months' duration, affecting the left hip, shoulders, wrists and knees Pain and swelling present with deformity Past history did not include any mention of tuberculosis, "double pneumonia" thirteen years ago

X-ray of the hands showed changes in the joints, of a rheumatoid character In addition, there were physical signs in the chest of a cavity at the left apex, and X-ray confirmed this finding and added that there was considerable fibrosis round it

Loss of weight, 7 lb Sedimentation rate at one hour 12 mm W B C.

13,400 with normal distribution Sputum was negative. Mantoux positive at 1/10,000 with œdema the size of a sixpence.

During the course of treatment a hæmoptysis occurred

Case III

J C Male Age 63 Foreman packer

A case of rheumatoid arthritis, of six months' duration, with pain and swelling of the wrists, ankylosis of the shoulders, and an effusion into the

ough and sputum

hritis, and showed chea pulled to the right

Sedimentation rate at the time of biopsy was 48 mm at the hour. Mantoux test was positive at 1/10,000 with erythema and induration to the size of a shilling

W B C not examined

Case IV

J T Male Age 62 Dock labourer

A case of osteoarthritis in the knees, of ten years' duration Similar changes in other joints, but these are asymptomatic, whilst the knees show considerable swelling and are the site of much pain

There was little in the past history except an attack of gonorrhœa in 1894

The X-ray confirmed the diagnosis, and also showed a cavity at the left apex The sedimentation rate was 3 mm at the hour. W B C 8,600, with

tic smear was

d pressure of

Biopsy was taken from the left knee

This is the only case of osteoarthritis in the series.

Case V

W H Male Age 27 Machine minder

A case of rheumatoid arthritis, of nearly two years' duration It began in the wrists and spread to nearly all the joints in the body The illness started with a conjunctivitis in the left eye and the patient was pyrexial for six months in another hospital

There was a past history of pleurisy and the shadow of a pleural effusion

no actual record is available

Sedimentation rate at the hour—30 mm W B C 5,600 with a relative lymphocytosis Mantoux positive at 1/10,000 dilution erythema and œdema the size of a shilling

He was treated with old tuberculin injections for nine months, without effect The left knee was the site of considerable synovial swelling without effusion

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At my request, Profes
report on his findings.

REPORT BY PROFESSOR WILSON

Examination for Tubercle Bacilli of Material taken at Biopsy from Patients suffering from a Rheumatoid Type of Arthritis

The material, consisting of synovial membrane, with sometimes *synovial fluid in addition*, was examined microscopically, culturally and by animal inoculation.

Microscopical Examination

Films were stained by Ziehl-Neelsen.

Cultivation

The synovial fluid was inoculated directly on to tubes of egg medium The synovial membrane was cut into small pieces with sterile scissors, ground up in a Griffith's tube, and suspended in a small quantity of sterile distilled water; after the suspension had been allowed to stand for a few minutes, the supernatant fluid was distributed over the surface of egg-medium slopes. If there was any doubt whether the material had been collected under aseptic conditions, part of it was treated with 5 per cent. NaOH or 6 per cent H_2SO_4 before being used for cultivation. Usually about 15 tubes of Dorset egg, glycerine egg, egg yolk, and glycerine-egg yolk media were inoculated The tubes were sealed with cotton-wool plugs impregnated with a paraffin-vaseline mixture. They were incubated at 37° C and, unless contaminated, were not discarded for six months

Animal Inoculation

A portion of the synovial membrane was introduced under ether anæsthesia into a subcutaneous pocket made in the left thigh of each of two guinea-pigs Part of the synovial fluid, if available, was inoculated intramuscularly into the opposite thigh. The animals were killed seven to eight months later, and examined very carefully for evidence of tuberculosis

Results

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[illegible]

Cour [illegible]

this [illegible]

his work (Reitter and Lowenstein, 1934).

Joint biopsy with expert bacteriological examination, using all methods is the only way to resolve this difficult problem So far as a few cases can be held to be of value, the evidence submitted here is against the idea of tuberculous rheumatism.

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Professor Wilson has made a special report to the Medical Research Council (No 182), dealing with Lowenstein's work It appears from this that a certain dissatisfaction exists with the technical aspect of his work (Reitter and Lowenstein, 1934)

Joint biopsy with expert bacteriological examination, using all methods is the only way to resolve this difficult problem So far as a few cases can be held to be of value, the evidence submitted here is against the idea of tuberculous rheumatism

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CHAPTER XVIII

SUBCUTANEOUS NODULES

THE first detailed observations on subcutaneous nodules were published by Meynet in 1875, and since that day a great deal of work has been carried out on the elsesions.

The appearance of nodules is not confined to rheumatic fever and rheumatoid arthritis, they have been studied in yaws and syphilis, and in 1930 the Harvard Expedition to Liberia and the Belgian Congo studied them in cases of filariasis. Hopkins (1931) described subcutaneous nodules in cases of syphilis and rheumatoid arthritis, and concluded that they could not be differentiated. A study of the *microphotographs appears however to show considerable variation* in the case of syphilis, one nodule was a xanthoma. Most of the nodules disappeared under antisyphilitic *treatment*. They were principally situated in the extensor surface of the forearms and over [illegible]

giant cells round

Differential Diagnosis

Apart from nodules occurring in yaws, syphilis, acrodermatitis chronica atrophicans, and other conditions, a *differential diagnosis* has to be made from other small tumours. Neurofibromata and gouty tophi may sometimes be confused, also small bursal and synovial cysts. A ruptured sebaceous cyst or a traumatised area of fat or connective tissue may resemble a nodule but the diagnosis is usually clear

The Typical Subcutaneous Nodule in Rheumatoid Arthritis and Rheumatic Fever

To distinguish these nodules in rheumatoid arthritis they are usually referred to as "necrobiotic nodules of rheumatoid arthritis type."

The following table, modified from M H. Dawson (1933), gives the main characteristics of these nodules in the two conditions.

A COMPARISON OF THE FEATURES OF SUBCUTANEOUS NODULES

Rheumatic Fever	Rheumatoid Arthritis
Frequency.—10–25 per cent.	7–25 per cent.

Situation —Approximately the same in the two conditions but in R.A. the elbows are most frequently affected, whilst in Rh F. the occiput, ankles, and knuckles show a high proportion of nodules

Rheumatic Fever	Rheumatoid Arthritis

In the latter they are also found in the dermis and in aponeurotic expansions

Trauma —In both cases subject to trauma but less so in rheumatic fever because of their rather different situation

Size —Small	Larger

In both cases depends to some extent on their duration and the age of the patient

Number —Nearly always multiple	Sometimes single Seldom multiple
	Any time
prognosis	Usually found in severe cases Biopsy necessary to determine type

Histological Evidence

Information as to the origin and formation of nodules has been obtained both from a study of the diseases with which they are



Fig 118

A subcutaneous rheumatic nodule

connected, and of their histological structure The latter source has been by far the most fruitful and it is now generally agreed that there are *three* (or sometimes four) "*zones*" in these nodules, the *central zone* of necrosis, the *intermediate zone* of cellular proliferation, generally in a palisade arrangement, and the *peripheral zone* of vascular proliferation in which it is thought the nodule develops A careful study of

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Differential Diagnosis

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The Area of Central Necrosis or Fibrinoid Degeneration

The fibrinoid change is more usually found in rheumatic fever, necrosis and degeneration in rheumatoid arthritis.

In rheumatic fever, the swollen acidophilic strands showed evidence of exudation of plasma and fibrin, and these present a "latticed" arrangement. Rheumatoid arthritis shows a typical area
edge of this zone embraces a
nediate zone shows œdematous
inflammatory cells in cases of
rheumatic fever, whilst the palisade of fibroblasts is seen in rheumatoid

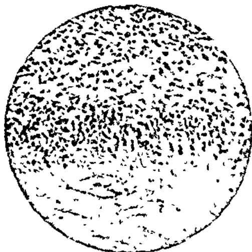


FIG 120

Microphotograph Showing the palisade arrangement of fibroblasts (Dr. Lowenberg's report)

arthritis This arrangement consists of a corona of mesenchymal cells, most of them fibroblasts with a few cells with large pale reticulated nuclei.

The peripheral zones are not of diagnostic significance In rheumatic fever this zone exhibits hyperæmia, and perivascular exudation, whilst in rheumatoid arthritis some thrombosis of vessels is seen

In older nodules, dense organised fibrous tissue surrounds the necrotic mass Foreign body giant cells with cholesterol clefts are occasionally seen in rheumatoid arthritis. Collins (1937) says that even after twelve to fifteen years the necrotic mass still lies within its fibrous capsule The smallest palpable nodule may contain only one focus, but most nodules contain many foci in different stages of development.

No conclusions can be drawn as to ætiology from the histological appearance Micro-organisms have never been isolated, culture and animal inoculation are negative. More work is required as to the

eight papers written between 1926–40 shows general agreement on this point. No such agreement can be found as to the relation of these nodules to one another. General opinion is that, when they differ, the nodule of rheumatic fever represents exudative phenomena, with injury to small blood vessels and exudation of plasma and cellular constituents into the connective tissues, whilst the nodule of rheumatoid arthritis represents principally proliferation and degeneration of connective tissue. Bennett, Zeller and Bauer (1940)



FIG 119

Microphotograph. Showing an entire nodule. Areas of necrosis with fibroblastic reaction and the well-defined edge of the whole nodule are shown.

checked their pathological conclusions with their clinical findings in 44 patients. Close correlation was found, but in at least 7 cases the changes they found were more compatible with the opposite disease.

General Description

The earliest pathological change is thought to be of vascular origin in rheumatic fever, and of connective-tissue origin in rheumatoid arthritis.

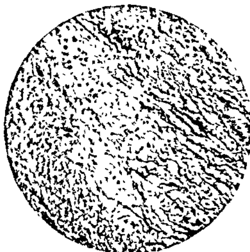


Fig 122

Microphotograph The bottom portion shows the necrotic area with a band of foam cells above it The top section includes the collagen fibrils with part of the fibroblastic reaction (Dr Lowenberg s report)

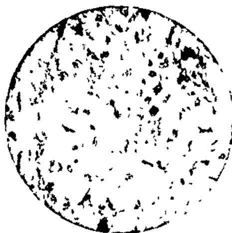


Fig 123

Microphotograph This shows at the top right a foreign body giant cell, the centre portion shows foam cells with vacuoles (Dr Lowenberg s report)

possible rôle of hypersensitivity. A section on the traumatic nodule follows.

The Traumatic and Induced Nodule

In 1883, F. D. Drewitt suggested that trauma might be a factor in producing nodules, basing his view on the exposed position in which they lie. Since then attempts have been made to induce nodules by trauma. Massell, Mote and Jones (1937) tried to produce nodules by



Fig 121

A subcutaneous nodule (with lipoid deposition) in a case of rheumatoid arthritis

trauma in 82 patients with rheumatic fever and chorea, using 34 other patients as controls. This was attempted by injecting the patient's own blood into the region of the olecranon process after local anæsthesia. In the following ten days the injected elbow was rubbed on the bedclothes several times a day for some minutes. Of the rheumatoid patients with clinical evidence of disease 90 per cent. developed nodules whilst only 3 per cent. reacted amongst the controls. These workers then studied the histology of these nodules. They concluded that, although the injection of blood had to some extent altered the histology of the induced nodules, yet it was still very similar to that found in spontaneous nodules, and that clinically they were indistinguishable. This seems to show that trauma plays a part in the production of nodules.

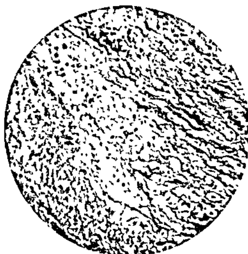


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CHAPTER XIX

SKIN MANIFESTATIONS IN RHEUMATISM

PATIENTS with rheumatoid arthritis usually have cold, clammy hands, and the feet are sometimes similarly affected. An erythema of the thenar eminence is sometimes very noticeable The skin of the rheumatoid patient assumes the temperature of its surroundings sooner than the skin of normal persons, and the reaction to heat and cold is poor and slow

It is difficult to make any estimate of the incidence of skin *lesions in the rheumatic diseases* In 1940, a *report was issued on the* epidemiology of acute rheumatism in South Australia and it was stated that 5 3 per cent of cases showed skin lesions

The commonest skin reaction is an erythema Two types are seen occasionally, *erythema multiforme*, and a type which occurs in rings, *erythema annulare* The latter is found on the body and on the flexor aspect of the limbs It only lasts a few days and then fades, but may herald the onset of a rapidly fatal rheumatic fever

Erythema multiforme generally appears on the backs of the hands and the forearms, and the backs of legs and feet. It is said to be associated with focal sepsis of streptococcal origin

Peliosis rheumatica, or Schonlein's Disease, is not very uncommon A purpuric skin rash is associated with a purpuric condition in the joints It has no association with rheumatic fever It is mentioned here because it is a useful point in differential diagnosis.

Henoch's purpura may also be associated with pain in the joints, but is characterised by violent colic and melæna

Hereditary purpura simplex —Eli Davis (1941) studied 27 family histories in which 88 members showed spontaneous ecchymoses (84 were females) Of the 88 cases, 79 had purpura simplex, 6 purpura of the Schonlein

and one boy

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arthritis, and others of severe fibrositis Sixty of the eighty-eight showed evidence of rheumatic fever, rheumatoid arthritis or fibrositis Some showed evidence of pulmonary tuberculosis.

On this basis Davis suggests a special connection between the rheumatic diseases and purpura

Erythema Nodosum

The ætiology of erythema nodosum has recently been reviewed in a Bradshaw Lecture (Bruce Perry, 1944) It will be sufficient here to state his conclusions and the reader is referred to the original lecture for further details.

Other Subcutaneous Nodules found in Rheumatoid Arthritis

Of recent years nodules other than the necrobiotic nodule of rheumatoid arthritis type have been described Parkes Weber and Freudenthal (1937) described a case which they termed "necrobiotic nodules of the rheumatoid arthritis type with lipoid deposition," and Fletcher (1946) described a similar case A characteristic feature

findings in both these cases was a complete absence of acid in the histamine test meal and a slight eosinophilia. A raised blood cholesterol was found in Parkes Weber's case and a raised sedimentation rate in Fletcher's.

The histological changes differ from the typical nodule, and the following is a summary of the report by Dr. Lowenberg in Fletcher's case.

"There is present deep subcutaneous nodule formation with an area of complete necrosis in the centre of the nodules, which in several specimens is surrounded by a cellular band which contains numerous "foam" cells and many multinucleated and foreign-body giant cells Surrounding this again is a partly degenerated connective-tissue band which contains, in addition to well-defined foam cells, numerous inflammatory cells. In other nodules the cellular ... The ... and ... show the presence of both intra- and extra-cellular cholesterol. As these are not true xanthomata, the words "with lipoid deposition" have been added to the description "necrobiotic nodules of rheumatoid arthritis type" A raised blood cholesterol has been recorded in one case The deposition of cholesterol in the absence of a raised blood level is, however, well recognised

Other *very rare* examples of subcutaneous nodules have been found in rheumatoid arthritis.

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The *nails* develop longitudinal striations and tend to break easily, pitting may be a marked feature Hyperkeratosis occurs and the nail may become loose on its bed Both hands and feet may be affected

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The ætiology of erythema nodosum has recently been reviewed in a Bradshaw Lecture (Bruce Perry 1944) It will be sufficient here to state his conclusions and the reader is referred to the original lecture for further details

112 cases were studied, 38 were males and 74 females. 61 gave a strongly positive reaction to 0·01 mg. of old tuberculin (a small dose was used because if the case is tuberculous it will be especially sensitive to old tuberculin), and 51 a negative reaction. X-rays were taken and certain patients subsequently developed undoubted tuberculous manifestations, such as tuberculous peritonitis Of the 112 cases 28 per cent were certainly tuberculous, 25 per cent. were probably tuberculous and 45 per cent. were definitely not tuberculous. Seventeen cases were tested with streptococcal nucleoprotein (Collis, 1932) and fourteen were positive.

Analysing the cases into age-groups of under 15 years and over 15 years, two striking facts emerged. *The sex incidence was quite*

2 males. In the under 15 group 43 per cent. were definitely tuber-

72 per cent of cases of erythema nodosum in children of school age or under are probably tuberculous in origin. This is borne out by occasional small epidemics of erythema nodosum, in which it is thought that an open case of tuberculosis is responsible for sensitising the group.

With regard to the relationship with acute rheumatism, ten cases gave a previous history of this condition, but in only two cases was there evidence of a rheumatic relapse and both followed the rash and did not appear coincidently

Perry concludes that erythema nodosum is a *non-specific pattern reaction* to various infections and toxins.

A history of a previous attack was given by thirteen patients All were females and tuberculin-negative. The only four tested were sensitive to Collis' streptococcal nucleoprotein. Eleven patients showed an antecedent acute pharyngitis and all but two had a negative tuberculin reaction

There is no doubt that erythema nodosum is also related to "San Joaquin" or Valley Fever This disease is caused by a fungus, *Coccidioides immitis.* Five per cent. of the patients develop erythema nodosum.

Kerley (1943) has described the chest X-ray findings in cases of erythema nodosum and concluded that the pulmonary shadows were much like those found in sarcoidosis. Histological examination of the skin lesions showed the characteristics of sarcoid 25 per cent.

nodosum

rash and it

Stannus has recorded that erythema nodosum is seen in the virus disease *lymphopathia venerea*

There could be two explanations for the cases connected with

rheumatism. Either some of the older authorities were right and there is a definite association between the two, or the skin sensitivity to Collis' streptococcal nucleoprotein indicates that the rash is linked with a streptococcus In any case, it is apparently necessary to *incriminate* another unknown factor as in the case of rheumatic fever. *It has been suggested* that a streptococcal infection may produce an attack of acute rheumatism and erythema nodosum without "the two being more closely related."

It must be stressed that attacks of erythema nodosum occur with some frequency in this country which do not appear to have a relationship with either tuberculosis or rheumatism Some cases of this type were published by Frankel (1945) His cases occurred in middle-aged women but some of them had a very severe clinical course He quotes nineteen cases which all recovered Streptococcal agglutina-

of the throat, they were thought to be due to sensitisation of the skin to streptococcal toxin Cases of this sort are seen not infrequently. They appear after a varied clinical course to recover, and there is no obvious association either with tuberculosis or rheumatism It may be that these cases have not been followed up for a sufficient length of time One has been watched since 1933 and is still well, but other long-term cases have been lost sight of since the war The very marked difference in sex incidence after the age of fifteen suggests some endocrine factor, but it must be remembered that certain Scandinavian authors do not confirm this finding (Mascher, 1943) It seems wise to regard a case of erythema nodosum as due to tuberculosis until it has been disproved

The Diagnosis and Treatment of Erythema Nodosum

The diagnosis presents no great difficulty The onset is variable, but is usually accompanied by mild constitutional symptoms such as pyrexia and malaise, with joint and muscle pain Later the characteristic erythematous nodules appear, usually on the shins, but occasionally on other parts of the extremities They vary from a few millimetres to several centimetres in diameter, are poorly defined and appear in sparse crops. The skin overlying the nodules is red, smooth and shiny Ulceration never occurs The nodules of Bazin's Disease are better defined, show a predilection for the calves, often ulcerate and last several weeks

Treatment

Every effort must be made to find the cause, whether this be tuberculous or streptococcal Valley Fever is never seen in this country and lymphogranuloma venereum is uncommon

Salicylates sometimes seem to help and occasionally quinine The usual attention must be paid to the general health, and a good tonic is helpful after the acute stage is over

Local treatment consists of applying lead and opium lotion to the lesions

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CHAPTER XX

ÆTIOLOGY AND PATHOLOGY OF OSTEOARTHRITIS

THE synonyms for this condition are numerous. Hypertrophic arthritis, degenerative arthritis, and arthritis deformans (Virchow) are commonly used. Osteoarthritis is generally accepted as the most suitable term, as it implies no special belief as to ætiology; degenerative joint disease is a common synonym in America. Osteoarthritis of the spine is considered in another section of this book. Because of the indelible mark it leaves on bones, the history of osteoarthritis has been traced through the ages. It is said that osteoarthritis dates back to the pre-human period of half a million years ago. The syndrome stands in marked contrast to rheumatoid arthritis.

Ætiology

Both rheumatoid arthritis and osteoarthritis occur more commonly in the female, but the preponderance differs considerably in the two

of osteoarthritis) occur so frequently in the female. A compensating factor is the incidence of traumatic osteoarthritis. Owing to the nature and condition of their work, men are the more frequent sufferers. These matters are fully dealt with in Chapter V.

Age incidence.—Osteoarthritis is a disease of middle and later life (in contrast with rheumatoid arthritis). Although it may commence at any age it is somewhat uncommon for symptoms to appear before the fifth decade, and the incidence is correlated with age. Even those cases associated with direct trauma are more common in the later age-groups. For further details of age incidence consult Chapter V.

The cause of osteoarthritis is unknown.—Endocrine dysfunction, chronic vascular disease, either local or general, metabolic disorders, focal sepsis, local aseptic necrosis of bone, or simple degeneration of cartilage with the passage of the years have all been suggested as ætiological factors.

Some physicians still adhere to the view that *infection*, either of a general or focal nature, has importance. On the whole, however, opinion is hardening against this view. The evidence in favour is negligible. There are no signs of constitutional disturbance, no loss of weight; fever and tachycardia are seldom seen. The white count is usually normal, and the sedimentation rate low. Agglutinin reactions to the streptococcus are feeble or absent. The clinical picture is not that of infection and removal of suspected foci of infection unfruitful. Secondary anæmia is unusual unless complications are present. Ankylosis never occurs. The morbid anatomy

does not suggest infection, and the only evidence in favour is an occasional flare-up of an osteoarthritic joint associated with heat and tenderness

Endocrine factors are sometimes said to play a part.

The physiological and artificial menopause.—In the female the menopause (either physiological or artificial) may be a factor. In 254 cases of rheumatoid arthritis the percentage incidence of the menopause was 9 7, and 18·0 in 253 cases of osteoarthritis This bore some relationship to the age incidence of the two conditions and no conclusion could be drawn from it. It has been said that there is a particular type of osteoarthritis of the knees, associated with the menopause, and some regard it as a form of hypertrophic synovitis, known as a *villous arthritis* It is said to be characteristic of the menopause, and to differ from osteoarthritis.

Stone (1938) obviously referring to such a condition agrees with this view, and says that "villous arthritis" is in fact a "hypertrophic fatty villous synovitis" and has no relationship to osteoarthritis. He mentions the question of obesity and says that the fatty synovial deposit may be part of the general condition. It is rare in men, and the condition will be relieved if the obesity is treated by thyroid and diet, and if œstrin is given. Pyretic baths are recommended on the basis of water and salt elimination Osteoarthritis supervenes if the knees are left untreated.

Of a series of 103 cases of osteoarthritis, analysed in 1939, 15 came into a group comprised of cases at or about the menopause (14 5 per cent. compared with 18 0 per cent. in the group of 253 cases).

They were distributed as follows.

Distribution of the Cases occurring at the time of the Menopause among the Clinical Groups

Group	Cases
Groups A and D (no associated clinical characteristics)	7
Group B (obesity only)	5
Group C (obesity and high B.P.)	3
	15

On this basis, 21·2 per cent. of the cases with no associated characteristics, and 11·5 per cent. of the cases with obesity and/or hypertension occurred at the time of the menopause. The joints first affected were all knees with two exceptions. As it was expected that obesity and/or hypertension would lead to a greater number of cases at the menopause, it was decided to analyse the age incidence in these groups in the whole series considering the females only, so as to see whether any differences found here might account for the figures (see table, p. 307).

Most people would agree that obesity often follows, or may appear synchronously with, the menopause, and it is uncertain whether the fatty infiltration of the synovial membrane is simply a part of the general obesity or whether there is a selective deposition, as some think,

the knee joints It is clear that such a deposit occurs, for it has en seen at operation, but not in patients who were of normal weight. n theoretical grounds there is no great objection to the idea that ch a fatty synovitis might be a cause of pain apparently referred the knee joint, for we know well that fat may be painful, as is most equently seen in Dercum's Disease, but also in adiposis dolorosa xta-articularis and in panniculitis, and in the back (see chapter on brositis) Under such circumstances a diagnosis of menopausal atty) arthrosis might well be made.

Age Incidence in the Two Main Groups of Osteoarthritis (with no associated characteristics and with obesity and or hypertension)—Females only

	Below 35	35–44	45–54	55 and over	
roups with no associated characteristics	1 (4%)	3 (12%)	5 (21%)	15 (63%)	=24 cases
roups associated with obesity and or hypertension	.	2 (3%)	21 (33%)	41 (64%)	=64 cases

It will be noticed that in both groups over 60 per cent of the cases ere 55 years of age and over, and that there is no significant difference the two groups There do not appear to be any published figures ith which to compare this table, but from a survey of the literature seems as if the series dealt with here tends to be rather older than he average, and that the menopausal influence would tend to be ninimised The association of obesity and hypertension with the enopause has been too well shown to be seriously doubted Gram 1930) recognised what he called the symptom triad of the *postlimacteric period* (adiposis dolorosa, arthritis genu and hypertensio rteriolis) He found hypertension and arthritis without obesity and rthritis without obesity in only 4 of 149 patients and obesity and

nd mentions the possibility of its relationship to changes in the ituitary basophil cells There may however be a different explanaion of Thomson's (1936) observation that the hyperpiesia of the menopause passes away in two or three years Most insurance loctors at any rate in America where hyperpiesia is common are amiliar with the type of recurrent hyperpiesia where high blood pressure seems to come in 'attacks,' each attack making it more ikely that further attacks will eventuate until the condition becomes permanent Whether hyperpiesia is considered to be permanent or emporary in any particular case would therefore depend on the imes when the examinations were made and the relative intervals between them This type of recurrent hyperpiesia is common in England but it has little relation to the menopause

The artificial menopause — An artificial menopause had been induced either by radiation or operation in thirteen cases of a series of 340 mixed cases of rheumatism. Of these thirteen, five were suffering from rheumatoid arthritis one was suffering from osteoarthritis of the spine and seven came into the group of general osteoarthritis, e g

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6·7 per cent., a little less than half the proportion of cases connected with the ordinary menopause Of these seven cases, *two showed* neither of the associated characteristics; four were obese, and two had high blood pressure

It has been noticed that although *this type is very resistant* to treatment, it is here that œstrin gives its best results

The clinical impression is that the artificial menopause is an *important factor in its association with arthritis* It is generally thought that under normal circumstances the thyroid takes over the metabolic function of the ovary at the menopause, under the control *of the pituitary* If, *however, as in the artificial* menopause, the metabolic demand is sudden, adjustment is more difficult, and the symptoms may be due to an inability of the thyroid to accommodate *itself* If this is so, subthyroid phenomena develop, and the appearance of a villous synovitis and certain fibrositic symptoms may be attributable to this factor This explanation hardly covers all the [illegible] natural [illegible] as been [illegible] rtificial menopause may show the characteristics of rheumatoid arthritis [illegible]

shown that severe joint changes may be produced in guinea-pigs, by the injection of *anterior pituitary substance* Degenerative changes have been shown in the articular cartilage Some changes also occurred in the epiphyses Apparently the rhythm of dividing cartilage is altered, and in [illegible] Changes were also noted in artic[illegible] of other endocrine extracts, such [illegible] erimental acromegaly with articular lesions was produced by Putnam *et al*, (1936) Nevertheless, the distribution and character of the articular lesions in acromegaly is not typical of osteoarthritis. The clubbing of the fingers in bronchial carcinoma has been attributed to dyspituitarism

The thyroid gland is said to be involved This is partly owing to the unusual incidence of obesity in osteoarthritis (which is discussed later), but in addition, Monroe (1935) found osteoarthritic changes *in a third* of all his cases of myxœdema This compares with an incidence of 1 6 per cent. in 414 cases of hyperthyroidism The occurrence of obesity and/or hypertension in osteoarthritis is a *prominent feature* In a recent series of 253 cases (Fletcher *et al.* 1945), including cases of osteoarthritis of the spine, the obesity rate was 47 3 per cent. and the hypertension incidence 41 2 per cent, as *compared with* 6·2 per cent and 6 4 per cent. in a series of general medical cases These figures are highly significant and the tendency is to explain them on an endocrine basis, the thyroid being especially *implicated* Unfortunately, the B M R. will not fully support this theory, the rate, however, is less than minus 15 per cent in a third

of all cases of osteoarthritis The blood cholesterol is usually said to

Hypertrophic pulmonary osteoarthropathy is sometimes associated with myxœdema, and in some cases occurs after subtotal thyroidectomy (Cushing) It is possible that some of the difficulties mentioned could be lessened by a more direct implication of the pituitary gland.

Experimental Osteoarthritis

Albert Key (1933) produced osteoarthritis experimentally by the injection of varying dilutions of hydrochloric acid, sodium hydroxide, distilled water, or salt into joints Synovial effusions followed The superficial cartilage cells sometimes survived, but the deeper ones died and made an effort to regenerate by the formation of cell nests and fresh hyaline matrix, but if erosion occurred, eburnation followed

producing passive congestion by the ligation of veins (Bernstein, 1933) Degenerative changes were produced in the knee joints of dogs, but the bone appeared to be atrophic and decalcified

All that can safely be deduced from such experiments is that injury and interference with the circulation of joints may lead to lesions of the articular cartilage

Chronic Vascular Disease

A great deal has been written on the effect of arteriosclerosis (either local or general) in the pathogenesis of osteoarthritis Monroe found clinically important arteriosclerotic heart disease in 18 per cent of his cases Bezancon and Weil (1934) point out that the marginal portion of the articular cartilage is nourished by the circulus articuli vasculosus but that the central portion is avascular, although it may be nourished by the synovial fluid Its regenerative power is small and the peripheral portion reacts by proliferation This is well recognised, but it is uncertain whether the peripheral portion of the cartilage will react by proliferation if the *blood supply is normal* Strangeways (1920) suggested that a narrowing of the synovial vessels would reduce the nutritive properties of the synovial fluid and Cecil (1930) regarded endarteritis as a possible ætiological factor It has been found (Pearson, 1928) that as a result of arteriosclerosis affecting the column of Goll, degenerative changes take place in the posterior root fibres and vibration sense is diminished It has been suggested that arteriosclerosis exerts its influence in osteoarthritis in this way, and not through interference with the blood supply of the joint Schmorl and Junghanns (1932) were unable to confirm that arteriosclerosis was the cause of cartilage degeneration and Bennett *et al* (1942) came to the same conclusion There is no doubt that arteriosclerosis cannot yet be regarded as a proved factor in osteoarthritis

Metabolic Disorders

It has always been said that osteoarthritis occurs in *alkaptonuria* and the staining of the cartilages by oxidised homogentisic acid is known as ochronosis. Staining of the cartilages can also be produced by the *prolonged use of carbolic acid preparations*, or may occur in connection with melanuria The melanin which produces the tissue-staining comes from the protein molecule. Only in the case of true alkaptonuria do osteoarthritis and arthropathies occur. The condition is very rare, only sixty cases have so far been reported and the X-ray picture is almost typical It gives little information as to the ætiology of chronic non-specific osteoarthritis

Osteoarthritis may also occur in *gout*, the probability is that it is here due to chemical deposit and injury (see chapter on Gout).

As osteoarthritis occurs in alkaptonuria (ochronosis) and gout, it is thought there might be a metabolic fault. Probably this form of osteoarthritis is simply due to chemical injury.

Some authors (Watson, 1928) think that hepatic dysfunction plays a part in the ætiology of osteoarthritis and point to the excess of urobilin sometimes found in these cases. However this may be, the blood proteins are usually present in normal quantity and ratio, and the sedimentation rate is seldom raised

The Ageing of the Tissues

Many authors now regard the passage of time and the multiple microtraumata of everyday life as one of the most important ætiological factors in the production of osteoarthritis. In spite of its importance, however osteoarthritis cannot be regarded simply as a disease of old age, for patients as young as 30–40 years of age suffer from it, and many very old people are free from it. *Injury* has been much quoted as a cause of osteoarthritis but frank trauma usually produces the monarticular form, and this differs clinically to such an extent that it may represent simply a similar form of bone and joint reaction It has to be remembered that these structures are only capable of certain forms of reaction to any insult or injury. Monroe, however, states that 75 per cent of 466 cases showed evidence of mechanical stresses and strains and he regards *postural errors* as a common source of articular discomfort and degeneration. There is no doubt that such errors are often present and associated with obesity in many cases, but it is an everyday experience to meet patients in whom no such abnormality can be demonstrated.

The theory of *stress and strain*, a variant of the above, has been much discussed Beitzke (1912) found from post-mortem work that labourers suffer to a greater extent than sedentary workers. Heine (1926) in a very careful piece of work covering the investigation of 1,000 unselected autopsies found that 100 cases used to hard labour all their lives showed no greater evidence of osteoarthritis than 100 cases who had done sedentary work. The varying results found in this type of investigation make it likely that a satisfactory key to the problem does not lie in this direction.

Corbin (1937) divided the lumbosacral roots which contain afferent fibres from the hip joint The *excessive range of movement* which resulted led to erosion and fibrillation of the cartilage and to enlargement of the head of the bone and the acetabulum, apparently with the object of giving better support to the limb This observation has never been properly evaluated but the work should be repeated The type of osteoarthritis found in tabes dorsalis and syringomyelia should be considered in this connection as excessive range of movement may well be comparable to movement at a mechanical disadvantage Amprino and Bairati in a series of papers extending over 1933 and 1934 showed that *cartilaginous degenerative changes similar* to osteoarthritis could be observed in the hyaline cartilage of the ribs and trachea, where the stresses and strains found in joints do not occur In dealing with the question of stress Heberden's nodes are often discussed It seems clear that some of these nodes may be due to stress whilst others are not For instance, they occur with some frequency in violinists and could in these cases be partly explained on an occupational basis

Bennett *et al* (1942) have recently investigated the knee joints of individuals at different ages They obtained knee joints from 63 cases, either at post-mortem or after amputation in whom no articular symptoms had been complained of The joints were carefully secured and their nutrient arteries hardened and then X-rayed Photographs were secured of the joints after they had been opened The articular cartilage was divided for purposes of description into sections so that it could be decided whether one part was more affected than another and the same procedure was carried out for the synovial membrane Macroscopic and microscopic studies were made *In every subject beyond the age of fifteen some degeneration was found in the knee joint* It is uncertain whether the changes they observed are identical with those of osteoarthritis but they are certainly similar *Advanced changes showed no corresponding X ray appearance* It is probably safe to assume that once degenerative changes have occurred in the hyaline cartilage the effect of joint movement considered from the point of view of weight bearing, as well as free movement, will result in diverse changes in cartilage subchondral bone menisci and synovial membrane A great deal of experimental proof supports this, but the exact rôle of weight bearing as opposed to free movement is uncertain As long ago as 1908 Walkhoff laid stress on the *subchondral condensation* which he attributed to weight-bearing and Timbrell Fisher holds the same view Bennett *et al* concede this point, and it has been shown in cases where experimental disalignment of joints has taken place Bennett only found subchondral condensation in cases where advanced cartilaginous lesions occurred Bennett's book is the most careful and painstaking study of the knee joint so far available, but its interpretation is fraught with difficulty If changes in the articular cartilage are present in all cases over the age of fifteen it may presumably be deduced that wear exceeds repair even at that tender age If so, how does it come about that symptoms generally appear late in life or not at all in some people? If the

ageing of a vulnerable tissue is the basis of symptoms, how do morbid changes occur so early in life? Bauer and Bennett seem to show that this question of age was of some importance and Bennett *et al.* confirm it, as also did Keefer *et al* (1934). The whole problem seems *to hinge on whether the changes in the hyaline cartilage are the* primary changes in osteoarthritis. The evidence so far indicates that they are, and this theory has been widely accepted since Weichselbaum (1872) first proposed it. On this basis such changes as are *found in the other articular components are secondary to this primary* degeneration The central avascular portion of the articular cartilage is apparently nourished by synovial fluid and has a definite respiratory power, so that it is not the kind of devitalised tissue which some authors depict Nevertheless, it is at some considerable disadvantage as compared with the peripheral portion. Bowie *et al* (1941) found that the respiratory power of cartilage gradually fell with advancing years, and this may be a reason for its greater vulnerability at that time

A point which is sometimes raised is the question of the apposition of a cartilage with its fellow. The importance of this is so far unsettled, but if an articular surface is denuded of its cartilage, its opposite fellc [illegible] Some authorities say that app [illegible] grity of cartilage,

Perhaps the greater part of the difficulty in solving the problem of osteoarthritis lies in the interpretation of X-ray films, and in the *comparative paucity of post-mortem material. For instance, the* [illegible] formation dependent on

accepted by the clinician as evidence of "secondary osteoarthritis." It seems much more likely that it is merely a secondary vascular phenomenon, and if direct evidence of this could be obtained, either post-mortem or [illegible]
might well be clar [illegible]
and it would not [illegible]
affected and the synovial membrane and endochondrium to escape. Nevertheless it seems clear, and it has already been mentioned, that the vulnerability of the avascular central portion of the articular cartilage with the addition of an unknown factor x is *the essential* pathological lesion, and that the other findings are secondary and depend perhaps partly on the factor x, but more particularly on altered joint mechanics

In the traumatic variety occurring in a joint which previously gave no symptoms or signs, and which to all intents and purposes was perfectly healthy, this factor x is particularly evident, for many severe articular injuries clear up altogether and it is only in the few that osteoarthritis supervenes. The irreversibility of the process is very evident for these cases are hard to treat, but it is comparatively unusual to see the osteoarthritic process spread to other (uninjured) joints.

Bennett *et al.* (1942) found that the X-ray lagged behind the pathological picture and this again is a disadvantage

Pathology of Osteoarthritis

The *primary pathological lesion* is a slow invasive erosion and degeneration of articular cartilage, preceded by softening and followed by fibrillation This usually involves the central part of the cartilage and is accompanied by some hyperplasia of the near-by cartilage Small pits and depressions occur with fibrillation of the matrix The cartilage as a whole loses its blue white sheen and becomes dull and



FIG 121

Osteoarthritis

The specimen was obtained from an old bear at the Zoo

(By Courtesy of Dr Shackle)

lustreless and somewhat thickened The superficial cells become arranged parallel to the surface but in the deeper layers cells are gathered into clusters

Sometimes changes are found synchronously in the epiphyseal bone, but are often absent Small lacunæ and areas of rarefaction may be seen in the subchondral bone, and at a later stage the calcified layer covering the subchondral bone may be herniated into it Although the *synovial changes* are somewhat belittled to-day joints at post-mortem undoubtedly show large, thickened, pedunculated synovial masses which by metaplasia are sometimes converted into cartilage or fat These may be late changes for the tendency is to regard these changes as secondary to the lesion of the articular cartilage Even in early cases a villous synovitis may be present.

The *vessels* may show degenerative changes with intimal hyperplasia and endarteritis.

Loose bodies may be present in the form of fractured pieces of bone or broken-off villi Small pieces of cartilage may become detached and, as mentioned before, these small loose bodies tend to grow.

The *joint capsule* becomes thickened

Both *menisci* show degenerative changes, with fraying and splitting

Marginal proliferation is by no means always present. Nichols and Richardson (1909) thought the osteophytes were genuine intracapsular cartilaginous overgrowths. Other theories are that they are due to periosteal activity or to endochondral ossification Callender and Kelser (1935) considered they were due to metaplasia of newly formed fibrous tissue They are most often found at the periphery of the joint surface between the articular margin and the synovial membrane

Advanced changes include gradual disappearance of the articular cartilage with eburnation of the underlying bone Secondary changes occur in the capsule, tendons and periarticular tissues Subluxation and instability of the joint follows Marked thickening of bone trabeculæ is a compensatory phenomenon. Ankylosis and effusions are very uncommon

Heberden's nodes differ somewhat in their pathology. The outstanding early change is loss of cartilage, not as a rule in the central portion but on one side of the joint This is due to the degenerative changes previously mentioned, and is closely followed by marginal proliferation with osteophyte formation The nodes themselves are due to a mushrooming of the terminal phalanx, due to a periostitis or osteitis In some cases the perichondrium becomes very active and cartilage, later formed into bone, may appear in islands round the joint

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CHAPTER XXI

DIAGNOSIS AND TREATMENT OF OSTEOARTHRITIS

Symptoms of Osteoarthritis

THE outstanding symptom is *pain*. Osteoarthritis of the hips or traumatic arthritis of any joint are the most painful varieties. The pain is usually referred to the joint itself, but in the case of the hips, for instance, it is often referred to the knee It is usually worse on movement and especially after exercise on weight-bearing joints Rest pain can, however, be a difficult complication Pain is said to be due either to marginal proliferation of bone, to pressure on exposed subchondral bone, or to fibrositis The distribution of *the nerve fibrils in the synovial membrane has been described in the* section on physiology, and pain could well originate at or about the junction of synovial membrane and cartilage The pain does not run *pari passu* with the clinical and X-ray changes. It is particularly severe after the appearance and resorption of an effusion.

Stiffness commonly accompanies the pain and is most noticeable after rest

Swelling may be due to fluid, but effusions are comparatively uncommon in osteoarthritis, and when they do occur may be accompanied by the classical signs of inflammation When these effusions resorb it is usually found that the condition of the joint has deteriorated

Bony swelling has already been referred to in the chapter *on Clinical Examination Some authors think that the bony swelling* seen typically in the femoral condyles and in Heberden's nodes is due to a periosteal reaction with the laying down of new bone, or activity of the perichondrium with formation of new cartilage, later becoming ossified

Tenderness comes and goes but is nearly always present in the stage of active advance Passive movement of the patella is painful at this stage

Limitation of movement may either be due to mechanical causes like contraction of the joint capsule or bony marginal proliferation, or to pain

Obesity and hypertension will be mentioned later.

Constitutional symptoms such as fever, tachycardia, or visceral lesions are hardly ever seen

Wasting of muscles is only seen commonly in osteoarthritis of the hips, where it appears regularly **Ankylosis** is rare except in the sacro-iliac joint and it is uncertain whether this is due to osteoarthritis

Crepitus

The wa ... nt **itself** are

fortunately ... ssibilities.

(1) **Heberden's Nodes**
(2) **The Carpometacarpal Joint of the Thumb.**
(3) **Osteoarthritis of the Knees.**
(4) **Osteoarthritis of the Hips.**
(5) **Senile Form.**
(6) **Monarticular or Traumatic Osteoarthritis**

It is important to remember this list as the subject becomes easier once it is recognised that these different pictures are to a large extent independent entities and can be separated clinically in the consulting room. Overlapping must naturally occur, but not as a rule until late in the disease.

(1) **Heberden's Nodes** are small cartilaginous or bony knobs situated at or near the terminal phalangeal joints. They were first described by William Heberden, the elder, in the eighteenth century. They affect all the fingers, but predominantly the index and middle finger. The thumb is seldom involved. Pulmonary osteoarthropathy or clubbing of the fingers is usually confined to the same region. Clubbing of the toes, however, is relatively common but Heberden's nodes do not affect the feet.

Heberden's nodes are divided into two types. The *primary or idiopathic variety* appears in middle aged patients as a rule and may be very painful in the initial stages. The *traumatic variety* may follow immediately after injury. A cricketer fielding on the boundary missed a high catch, the ball hitting the terminal phalanx and crushing the finger. That finger alone developed a Heberden node. At a much later date, however, nodes appeared on all the fingers.

In *both types* the cartilage of the joint is affected. Fibrillary degeneration and perichondrial activity with ' mushrooming ' of the joints appear. Periostitis and osteitis have been described with the formation of ' spurs '. The joints seem to suffer more on one side than the other, so that the terminal phalanx becomes displaced laterally.

The idiopathic nodes are found far more often in women than men (proportion about 9 : 1). The terminal joints are always involved. Occasionally the proximal phalangeal joints are affected (about 10 per cent. of cases), but the metacarpophalangeal joints always escape. The nodes only occur in osteoarthritis. This is in sharp contrast with the joints involved in rheumatoid arthritis.

The *onset* is usually gradual and extended over months, very rarely the nodes may develop rapidly. They are painful in the beginning and very occasionally show evidence of inflammation. Finally the pain and tenderness disappear. Persistent bony knobs remain which are painless. The patients are very sensitive as to the appearance of the fingers.

The nodes are rarely associated with small nodules which appear in pairs over the dorsal aspect of the fingers between the proximal and distal joints.

Stecher (1940) supported the view that heredity has a high place in the aetiology of the nodes. He found with traumatic and idiopathic



Fig 125

Heberden's Nodes Note the "mushrooming" of the terminal joints, with the lateral displacement of the phalanges

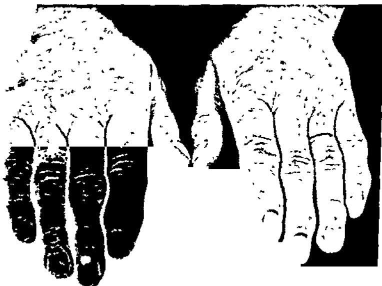


Fig 126

Heberden's Nodes Typical appearance of the hands in this condition

Fig 127

An unusual appearance—nodules appearing on the terminal phalanges in association with Heberden's nodes

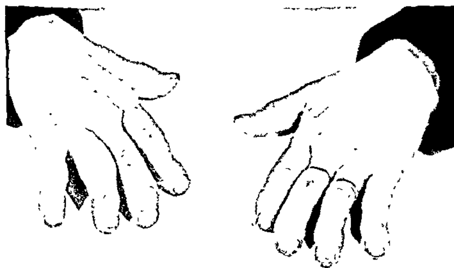


Fig 128

Another unusual appearance—twin nodules on the terminal phalanx with Heberden's nodes

nodes that the incidence rose with age. It is characteristic that the develop distal to the articular margin although osteoarthritis develop in the joints

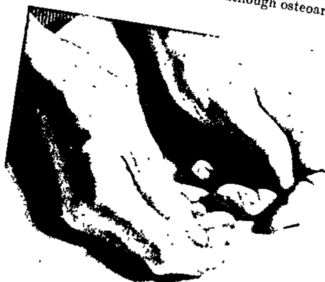


FIG 129

Osteoarthritis of the right carpometacarpal joint of the thumb This is a moderately frequent anatomical occurrence—the bulge of the joint is well shown in the right hand



A



B

FIG 130

Osteoarthritis of the carpometacarpal joint of the thumb

X-ray Appearances

Heberden's nodes show apparent loss of articular cartilage, with a good deal of "mushrooming" of the joints and some displacement of the terminal phalanx (see Fig 125).

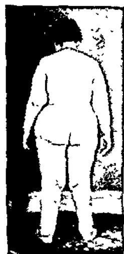
(2) **The Carpometacarpal Joint of the Thumb.**—Although the carpometacarpal joints of the fingers are so rarely involved in

teoarthritis, that of the thumb is frequently affected *That joint one* may show changes Usually it is the site of *swelling* and nearly ways of *crepitus* It tends to be unusually painful as it is a joint hich is involved in nearly all movements of the hand It is quite unusual to see this *joint the seat of rheumatoid arthritis* The welling is quite typical but not very noticeable, as the hands are ually held in the position midway between pronation and upination

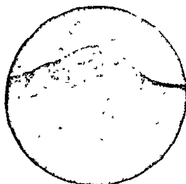
-ray Appearances

Carpometacarpal joint of the thumb shows osteophytic outgrowths ometimes with sclerosis of bone

(3) **Osteoarthritis of the Knees** is one of the most frequent and ost difficult forms of the disease It is commonly found amongst



A



B

Fig 131

A case of osteoarthritis of the knees Note the obesity, the pronated feet, and the knock knee The X-ray of a knee is also shown

a great problem

Grating of the patella is usual and crepitus of a coarse type is found in the joints Enlargement of the bone ends and synovial proliferation are common findings, so that the joint and its component bones make a considerable swelling Muscles and tendons become painful and tender, but there is little atrophy

A hundred and three cases of osteoarthritis were analysed to discover whether obesity by itself led to a greater strain on the knees as opposed to other joints Where obesity was a factor 74 per cent of cases had osteoarthritis of the knees, where it was not, 60 6 per cent only The difference is not great enough to be significant The

matter is further discussed under ætiology, but it seems as if the great predominance of the female sex may be a factor. The age incidence has also been compared In cases with obesity and hypertension, the average age is 56 5 years (highest 73, lowest 36), whilst in those without either of these associations the average age is 54·5 years (highest 71, lowest 26) There is no significant difference

Knock knees and other deformities are commonly found, and in typical cases the postural element is strongly marked. The protruding abdomen with the marked lumbar lordosis are potent factors in the evolution of this variety of osteoarthritis The possible association with the menopause has been fully discussed under ætiology.

X-ray Appearances

Osteoarthritis of the knees shows no loss of joint space. The cartilage if altered shows localised thickening in the form of a band.



FIG. 132

The first stage of osteoarthritis of the knee joint, the tibial spines appear to have been drawn out into fine needle points



FIG. 133

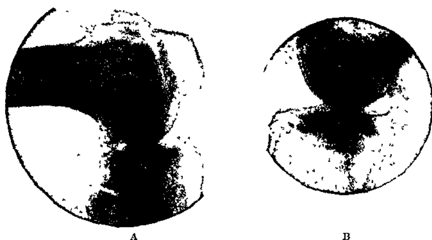
A more advanced stage than Fig 132, showing fracture of the tibial spine.

Sclerosis of bone not present but many osteophytes. Exceptionally there may be cartilage loss between the patella and the femur.

(4) **Osteoarthritis of the Hips,** with the exception of the purely traumatic type, belongs to the older age-groups, and differs much from other types. A number of these hips have been the site of past epiphyseal disease, or partial congenital dislocation. Pain is sometimes felt in the back. Some authors say that pain is commonly referred in the area of the sciatic, obturator and femoral nerves This is not usual, but the pain may be referred entirely to the knees, so that the tentative clinical diagnosis is made almost entirely on two physical signs

Limitation of movement may antedate all other physical signs by months or even years. The knowledge that there is any limitation

may be entirely hidden from the patient. In the course of the routine examination (see Chapter II) and with the patient supine, a rolling movement is imparted to each thigh in turn A limitation in this movement is the first physical sign obtainable. The feet are then taken, one in each hand, and an endeavour is made gently to abduct the thighs. Limitation of movement here generally indicates a lesion in one or other hip joint On account of a degree of fixed external rotation of the thigh, flexion is normally carried out with the ball of the foot scraping up the opposite leg This will occur whenever external rotation is a fixed feature, but osteoarthritis of the hips shows this as one of its characteristics Forward bending will



A B

Fig. 134

A. A so called "detached patella" Note the changes in the knee joint itself
B Osteoarthritis of the knees with very poorly calcified osteophytes.

be limited and this will be noticed more on the side of the affected hip,

abduct each leg separately, keeping the other in the mid-line. Certain muscle and tendon lesions give the same sign Flexion will usually be limited as well as adduction

Atrophy of muscle is said, in some text-books, to be absent This is entirely erroneous Atrophy occurs early, but not nearly so early as limitation of movement The principal sites are the adductors of the thigh and the glutei Each thigh should be carefully examined and measured six inches above the upper margin of the patella One hip is nearly always in a more advanced condition than the other and these measurements give valuable help The best way to observe the *general wasting* is to ask the patient to stand up and carefully examine

from the back With anything more than the very minimal degree of wasting, the difference on the two sides is obvious. With the patient standing, and with both feet flat on the ground, the degree of *tilting of the pelvis* is noted with its accompanying scoliosis If shortening is likely the two legs should be measured (*a*) from the anterior superior spine to the internal malleolus and (*b*) from the umbilicus to the internal malleolus If shortening is present, measurements are taken to find out whether this occurs above or below the great trochanter. With the patient supine, a vertical line is dropped from the anterior superior spine. This is best done with a short wooden rod *held against the* side. The perpendicular distance of the top of the great trochanter from this line is measured *and compared on the two sides. In the ordinary* adult the measurement is about 2½ inches. If required, the triangle can be completed by joining the anterior superior spine to the great trochanter (Bryant's triangle). *Nelaton's line* is drawn from the anterior superior spine to the most prominent part of the tuber ischii. The *centre of this* corresponds to the great trochanter. Both these measurements are useful as they indicate those cases where shortening of the femoral head or neck is a feature They are particularly useful in separating out old Perthe's Disease clinically.

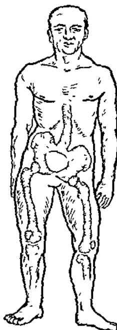


Fig 135

Osteoarthritis of the hip The pelvis is rotated towards the affected side, in order to bring the abducted limb into line with its fellow. In these early stages the flexion of the limb is masked by a lumbar lordosis.

Having diagnosed a *hip lesion in an elderly* patient, it is by no means settled what the lesion may be. Trauma is not a *common factor*, although there is no doubt that trauma can lead to osteoarthritis of the hip. Congenital dislocation of the joint, coxa vara, either adolescent or infantile, and Perthe's *Disease* are all conditions which may lead to osteoarthritis in later life. Paget's Disease (osteitis deformans) may frequently play a part. *Osteochondritis* dissecans occasionally occurs in the hip joint of young patients. *The gait and posture* of a case of osteoarthritis of the hip is fairly typical, but not as a rule decisive.

X-ray Appearances

Osteoarthritis of the hips shows loss of joint space *only* at the point of maximum pressure (Fig 137). This is very important as rheumatoid arthritis of the hips shows loss of joint space all round the joint Osteophytes are present in large numbers, occasionally small cysts are visible in the adjacent bones. Old Perthe's Disease is characterised by "mushrooming" of the femoral head, shortening of the neck and a marked coxa-vara deformity.



Fig 136

A case of old Perthe s Disease Note "mushrooming" of femoral head, the short neck and a degree of coxa vara.



Fig 137

A case of osteoarthritis of the hip, showing the pressure point at the upper part of the joint.

(5) **Senile Form.**—This is osteoarthritis in miniature It is the truly degenerative type of arthrosis. These patients are usually *spare and occasionally suffer from arteriosclerosis.* In my experience,
be a

uffer
ienic
than hypersthenic type, they creak and they grind through life with the minimum of pain and the maximum of inconvenience. They benefit by remissions and regressions, generally attributed to their latest treatment, but in fact part and parcel of their arthrosis. Advancing
and with ca
they be so
be serious Such joints tend to be very painful, most disabling and long continued.

(6) **Monarticular or Traumatic Osteoarthritis.**—This is a very painful condition. No joint is exempt. The usual ones are the knee, the elbow, and the hip. Trauma may precipitate any form of arthritis (rheumatoid, tuberculous, etc), and this has been held in the Courts. *Usually, however, the variety known* as traumatic arthritis follows. Osteoarthritis may be made desperately worse by a single blow.



Fig 138

Traumatic arthritis of the elbow in a stoker who had continuously knocked his elbow for years.

Types of injury are very various and range from one major motor-car accident to repeated tiny injuries such as knocking the elbow against an oven door (Fig 138) *Occupational arthritis* is generally included in this section as in most cases it is due to micro-injury. It is seen in the toes of ballet dancers, in the elbows of stokers *and in the hips of* acrobats

The condition is usually, but not always, monarticular. It should fulfil certain conditions if the diagnosis is to be
igns must
be present.
ot exceed
six months.
ings. It
must be clear that the condition is not periarticular If an effusion

acks is said to be the
nopausal. The usual
stigmata of myxœdema are described in these cases, the coarse skin and dry hair, mental apathy and *constipation are said to constitute*



FIG 139

Osteoarthritis of the shoulder This is a very uncommon condition. It will be noticed that the edge of the glenoid fossa can be seen through the head of the humerus and is elongated and extended throughout its margin



FIG. 140



FIG 141

FIG 140 —*Os acetabuli* is sometimes the forerunner of osteoarthritis of the hip It has to be distinguished from fracture of the rim of the acetabulum The femoral head lies half outside the acetabulum The X-ray is tilted to throw the shadow clear

FIG 141 The shoulder joint in Morquio's Disease.

a clinical entity Myxœdema is very uncommon in osteoarthritis, but obesity is very common. The age incidence makes it likely that a good many cases will appear about the time of the menopause.



Fig 142

The *hip joints* in Morquio's Disease.

Fig 143

The *spine*, in Morquio's Disease (see page 331)

Osteoarthritis of other joints conforms to the general pattern osteoarthritis of the knees, but *osteoarthritis of the shoulder* is a ve uncommon condition—the acromio-clavicular joint being more of implicated in this region

Paget's Disease (osteitis deformans) is often associated w osteoarthritis, but is dealt with in another chapter.

Laboratory Findings

Most of these findings are negative. As the *sedimentation rate* is very occasionally raised, 316 cases of osteoarthritis were analysed from this point of view (Fletcher, 1944). These also included osteoarthritis of the spine, which in this book is treated separately.

Taking 15 mm. at the hour (Westergren) as the top limit of normality, 7 per cent of cases of osteoarthritis of the hips were found above this limit, and for other joints (including the spine) 11 per cent., so that for all joints the average was 9 per cent All cases were excluded from this survey in which other causes for the raised rate could be found These causes included chronic nephritis, pulmonary tuberculosis, psoriasis, Paget's Disease, tabes, asthma, and a mediastinal effusion

An attempt was then made to separate out the group of cases with a raised rate and see whether they differed from the others. The result of this was negative, no difference could be found, and the separated cases were allowed to fall back into the main data The conclusion is that roughly one case in ten of osteoarthritis has a raised rate. Taking this into account it is indeed fortunate that the X-ray was found to be helpful in diagnosis in 94 per cent of all cases of chronic rheumatism

Apart from the low sedimentation rate there are only two helpful laboratory aids In about a third of all cases the basal metabolic rate is decreased, and in a comparatively small percentage of cases the blood cholesterol is raised (normal values in blood 150–230 mg. per cent). Neither of these tests is particularly useful, but a combination of clinical, X-ray and laboratory findings will allow a correct conclusion to be reached in the vast majority of cases.



FIG 144

Marquoi s Syndrome

The spine is flat in its lumbar portion Note the raising of the right heel

Differential Diagnosis

Consanguinity seems to be a factor, several cases have been described where the parents were cousins The tallest case described was four feet eleven inches The principal changes are said to occur in the spine, but any joint may be affected, and sometimes the costal cartilages show advanced calcification in the early twenties The



Fig 145

A case of acromegaly associated with osteoarthritic changes in the spine and knees



Fig 146

Acromegaly—to show the appearance of the spine The spine has rotated as the list has developed

principal factors are a malacia and a dystrophy, but the X-ray appearances in the joints are very similar to those of osteoarthritis, and are often mistaken for it. If the syndrome is suspected, X-rays



Fig 147

Acromegaly—to show the condition of the bones and the tufting of the finger-tips



Fig 148

The appearances in the knee joint in a case of acromegaly

of the lumbar spine should be taken The two changes shown are a widening and spreading out of the vertical bodies and the increased
aginous dystrophy is shown

rthritis, seen best in the
knees Associated changes are found in the spine, both in the

vertebral bodies and the intervertebral discs. The changes in the knees are not quite typical, as there may be loss of joint space. The associated features of acromegaly will be present, with the tufting at the tips of the fingers and broad puffy hands (Figs. 145–148).

Caisson Disease presents an arthritis difficult to distinguish from osteoarthritis. In the stages of decompression nitrogen accumulates in the bones and aseptic necrosis due to infarction may result from blocking of arteries. The knees are usually affected and secondary changes somewhat analogous to osteoarthritis occur.

The suggestion has been made that osteoarthritis may be caused by the prolonged use of *pneumatic tools* This must be very unlikely, the usual change seen being multiple areas of decalcification in the bones.

TREATMENT OF OSTEOARTHRITIS

In the chapters on ætiology and diagnosis it has been shown that the cause of osteoarthritis is not clearly understood. On the whole, the theory of ageing and trauma, stress and strain commands most respect, and the question of rest will be important in treatment.

Rest

Most patients are under the impression that they must use their joints as much as possible, and that if they do not they will become "crippled." *Over-use undoubtedly makes the osteoarthritic joint* worse, but complete bed rest is not as a rule desirable, except when an acute arthritic "episode" is in progress. During these inflammatory periods complete rest and even splinting becomes necessary, the joint being passively moved once each day. In the ordinary way the *question of rest should be decided on the character of the pain.* The pain of osteoarthritis can be classified on the following plan, and a study of the chart will indicate the place of rest in treatment:

TYPES OF PAIN IN OSTEOARTHRITIS

	Pain due to Capsular Fibrosis	*Pain due to Nipping of Synovia or Loose Bodies*	*Pain due to Fibrositis*	*Bone Pain*	*The Pain of an Acute Inflammatory "Episode"*
Character	Short and sharp	May be sudden and agonising	Aching	Constant and deep	Constant and deep
Location .	Depends on the position of the fibrosis	Over the joint	Round the joint	Variable	*Over the joint*
Effect of exercise	Bad	Bad	Not greatly affected	None	Very bad
Effect of rest .	Good	Good	Relieves	None	Relieves a little
Pain is affected by	Reproduced by putting joint through extremes of movement	Relieved by stretching the joint	Relieved by massage and made worse by pressure on the tender spots	Night pain severe, warmth makes it worse	Reproduced by active or passive movement
Joint stiffness .	Great	Moderate, but joint cannot be moved for pain *for some time*	Variable, often great	Little	Very great, joint hot and swollen

TREATMENT OF OBESITY

Obesity is generally divided into the exogenous and endogenous types. In the former type it can be attributed either to excessive intake or to decreased activity In the latter, there is a decrease in the fundamental rate of oxidation in the body, and these cases usually are of thyroid origin, pituitary origin, or gonadal origin Examples such as Dercum's Disease or Cushing's syndrome will readily occur. Such "endocrine" types are said to have a different distribution of fat In *hypothyroid* obesity there are generally pads of fat at the lower part of the neck at the back, over the clavicles and between the scapulæ, the

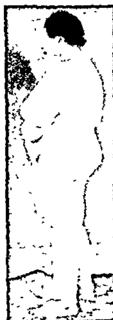


Fig 149

A case of obesity with osteoarthritis of the knees The fat shows no particular endocrine distribution

veneris, in the hypogastrium over the buttocks, and sometimes round the thighs; in adrenocortical cases the face is full and puffy, there is fat about the trunk, thighs and upper arms In *hypogonadal* states the upper part of the thighs and the mons veneris show the greatest deposit Thyrogenic obesity is not considered to be common Mild degrees of thyroid hypofunction may be suspected a good many times, but the effect of thyroid therapy is generally the deciding point.

As the type of obesity is often in doubt, Kestner and Plaut's test may be applied. They found that the specific dynamic action of protein was lower in pituitary obesity than in normals or in cases of thyroid obesity. A basal metabolic rate (B M R) test is carried out first Then 200 grammes (approximately) of egg are given An average egg weighs 2 oz., which equals 56 grammes approximately, so that four eggs average out about 224 grammes This is naturally very difficult now One hour later the metabolic rate is estimated again According to Kestner and Plaut the normal response to the protein lies between 25 and 30 per cent increase in the basal rate, while in cases due to pituitary influence it is only 11 per cent The blood cholesterol sometimes helps to distinguish thyroid cases Kestner's test is useful in the separation of different types of obesity, and so in treatment

Putting on weight is closely bound up with the question of fluid

retention in the body, and diet and medicines should be prescribed to deal with both these factors

Diet

Either the patient can go to bed for a week or two and fast, or the treatment can be carried out on a low-carbohydrate high-vitamin diet. It is much easier to treat the patient who can fast in bed, and in this case the only food allowed for the first week is fruit juice, not more than two pints a day. After the first day or two elimination should be assisted by calomel tablets grs 1/10 t.d.s. and a dose of salts each morning The patient need not stay in bed all day but can go out for a short walk and then get back into bed. In the second week coffee and milk can be allowed for breakfast, two meat sandwiches for lunch and cheese and salad at night. No salt must be allowed. Fluid intake must be restricted as before and, if weight is not being lost satisfactorily, fluid retention must be dealt with diuretics such as urea, salyrgran, mersalyl and ammonium chloride Adequate doses of thyroid extract may be useful. If the reduction is to be carried out while the patient is ambulant, exactly the same measures will be required, with the addition of a diet (for a patient of 12 stone) of 500–1000 calories Protein should not be reduced below 60 g. or body protein will be utilised. The saving must be made principally on carbohydrates. It is a good thing to remember the following list of *low carbohydrate vegetables*: nearly all the green leaf vegetables, e.g. cabbage, both types of broccoli, cauliflower, brussels sprouts, watercress, lettuce, endive, spinach, tomatoes, celery and asparagus. They are particularly useful in difficult cases who take badly to dieting, as they relieve hunger. With such a low calorie diet it is usual to give supplementary vitamins.

In a great many cases difficulty will be encountered in the reduction of weight and, as mentioned above, the answer to this problem will nearly always be found to be bound up with the question of fluid retention. Of the diuretics commonly used, the only one which is satisfactory over a long period, and is entirely non-toxic, is urea. The dose usually given is 5 to 10 grammes three times a day.

It is possible to increase the rate of weight reduction either by intensive exercise, which is a first-class ancillary measure, or by certain physiotherapeutic measures Of these the sweating treatments naturally occupy the first place, but it is as well to remember that these methods make a considerable demand on the cardiovascular system in elderly patients and should not be used without due consideration of this factor.

[illegible] in the treatment [illegible] be painful [illegible] hnoogra oil [illegible] The first injection, given deep into the glutei, is 1 c c, and 2 c.c. are added weekly till 9 c c. are being injected The oil should be warmed before being injected Twenty cases were treated, and fifteen or 75 per cent. showed great improvement. It seems likely that this

drug has value provided its use is carefully restricted to cases of osteoarthritis.

Adjustment of Posture

This is important The protruding belly with marked lumbar lordosis should be first reduced, but instruction in the correct posture must follow. More is said of this in discussing postural conditions

The Injection of Joints

The treatment of osteoarthritis has been a baffling problem for many years, and in consequence the actual injection of medicaments into the joints has received repeated trial Failure to maintain



Fig 150

A hip joint filled with lipiodol This case was rendered symptom-free till lost sight of

complete asepsis brought this method into disrepute, but it can be said now that with proper precautions, and the use of reasonable solutions, little danger attaches to the method

A pilot experiment was carried out with 20 cases, and lipiodol (Lafay) was used (Fletcher, 1943) Twenty joints were injected with lipiodol and eighteen of these were knees The proper control here is the comparison with cases of osteoarthritis of the knees treated in other ways, and so the two odd cases were discarded, and the eighteen knees used for comparison. Breaking the cases down into those with obesity and/or hypertension and those without, yielded no significant differences, so the two groups, one treated by injection and one treated by other methods, were compared as a whole. The table which follows shows the results obtained:

a knee is 10 c.c There is no doubt that pain is entirely relieved for a period. *The duration of this period varies* from four hours to a day. Succeeding injections as a rule are followed by prolonged periods of freedom, and in a very large number of cases the pain may cease entirely for months A good plan is to continue the injections, after the pain has been relieved, once every month or six weeks. Naturally



FIG 153

A small piece of the acetabulum has fractured This is one of the ways in which osteoarthritis may commence. (Compare with Fig 140)

enough the rationale is not understood, but the result attained follows the pattern obtained in other parts of the body, where the temporary interruption of pain sensation may in fact become permanent or semi-permanent, although the original pathological stimulus is not affected It matters little from the point of view of treatment whether the explanation is really of a psychological character.

Injection of Fat

Mortimer Woolf (1938) tried the injection of a patient's own fat in cases of intractable pain. The fat is obtained from the abdominal

vall, and is shaken in saline to wash off the blood It is then placed n a porcelain dish and cooked on a hot-plate. As the fat cooks it must be continually cut with scissors or it chars The oil which exudes is inally injected and the joint massaged. Of the 30 cases injected, 16 were successes, 3 doubtful and 4 good, but these could not be followed up. Cases sometimes do extremely well

Fluid Injection of the Hip

Waugh (1945) states that over a period of nine years he has injected 1,200 cases of "arthritis" with acid injections He based this treatment on his observations of the pH of the synovial fluid in various conditions. In osteoarthritis of the hip this was consistently on the alkaline side, as high as a pH of 8·8

Each week 15–20 c cm. of a solution of lactic acid of a pH of 5 8 with procaine are injected *in and around* the joint This is followed by gradual manipulation and flexion-extension-abduction exercises without weight-bearing 108 hip cases have been treated like this over five years Between 50 and 60 per cent have recovered sufficiently to follow their usual occupations The chief contra-indication is extreme loss of joint space The best results are obtained with in-patients.

18 cases are finally analysed Of these, 7 are classed "very good," and 7 good. (The recommended solution of lactic acid is obtainable from Brady and Martin, Newcastle on Tyne) It is difficult to express an opinion on this method of treatment Almost identical results

controls In any type of hip injection it is necessary to remember the necessity of complete asepsis Good results will not ensue unless the capsule is injected anteriorly, posteriorly and laterally Gentle stretching after the joint comes under the influence of the local anæsthetic is also an essential part of the procedure It is likely that this stretching of the capsule is the important part of the whole procedure in the case of the hip joint

The same principle is used in *gentle stretching of the capsule* under an anæsthetic

Intensive conventional diathermy sometimes relieves osteoarthritis of the hip for as long as a year. Small bare electrodes are applied anteriorly and posteriorly and down the iliotibial band, and are all connected to one lead from the machine A very large electrode is then placed over the lumbar spine and connected to the other terminal. Sessions for as long as two hours are given daily (except Sunday) for 12 days The technique is not easy, and it is difficult to free a machine for so long in most departments, but the method is sometimes successful where other treatments cannot be used

A *series of plaster spicas* gradually reducing deformity may give great relief.

In osteoarthritis of *other joints than the hip*, heat in any form does

good, and radiant heat is better than diathermy in superficial joints. Other useful treatments are *anodal galvanism* and *massage*.

Surgical treatment is especially useful in the case of the hip joint. Either a vitallium cap arthroplasty or a nail arthrodesis seems at the present time to be the most popular operation. A simple arthrodesis leads to bony union in only about 40 per cent. of cases. However, out of 110 operations on the hip joint for osteoarthritis of the hip, the following were performed at the Wingfield-Morris Orthopædic Hospital

Pseudo-arthrosis	44
Arthrodesis	24
Arthroplasty	12
Osteotomy	13
Reconstruction	6
Various	11

(Girdlestone, 1944)

Some surgeons think that a primary osteoarthritis of the hip is rare. They think it follows a vascular lesion with local avascular necrosis.

Magnuson (1941) has recently described an operation known as joint debridement He shaves away the roughened areas of cartilage and removes all exostoses which interfere with movement. The shaven areas become covered with fibro-cartilage and symptoms are relieved. He has been successful in sixty cases out of sixty-two. The cases have to be carefully chosen.

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CHAPTER XXII

OSTEOARTHRITIS OF THE SPINE

THE diagnosis of osteoarthritis of the spine is made fairly frequently, but it is not by any means the commonest of the medical locomotor disorders. In 1,500 carefully recorded cases of chronic rheumatism it occurred 84 times, 37 times in males and 47 times in females. This compares with 377 cases of infective arthritis in the same series, which also included 90 cases of ankylosing spondylitis The average age at the time of onset was 55 years The average duration of symptoms at the time of diagnosis was 23 6 months.

It may perhaps be as well to describe first the different conditions which appear to make up the generic whole They could be set down as follows.

Osteoarthritis of the Spine

(1) *Polyspondylitis marginalis osteophytica* (Shore) (hypertrophic spondylitis of the American authors)

(2) *Osteoarthritis of the spinal apophyseal joints* (hypertrophic spondylarthritis of the American authors)

Another condition will be mentioned here, *spondylosis ossificans ligamentosa* It is uncertain where it should be included, so it will be described briefly, and no further mention made of it

Spondylosis ossificans ligamentosa.—This is a condition which is characterised clinically by a pain in the back, with local ossification of ligaments as shown by X-ray films The clinical findings vary. Some cases show a local limitation of movement in the spine, others do not. The condition is uncommon, being rare as compared with the other types of osteoarthritis of the spine

The patients are nearly always of the age of 40 years and upwards and rather more females than males are affected They are not more often obese or hypertensive than might be met with by chance, and the X-ray findings are seen occasionally when no symptoms are present

The condition is found in the cervical and thoracic vertebræ in the greater proportion of cases, and it is just possible that some of these cases were quoted in an article on ankylosing spondylitis, in which a special group was separated which showed no sacral focus (Fletcher, 1944). There were 5 women and 3 men, with an average age at the time of diagnosis of 46 years The sedimentation rate was raised in 2 women and 3 men There was local calcification of ligaments in 3 cases (1 woman, 2 men) and local ankylosis of spinal joints in 5 cases (4 women [illegible]

spe

anc

Since then, however, 3 more cases have been seen, all with a normal sedimentation rate and all with local calcification of ligaments, and it seems possible that they would be included under the generic heading of osteoarthritis of the spine

Taking all the cases of this kind seen, therefore, they amount only to eleven, which is an indication of its rarity.



Fig 154

Example of polyspondylitis—anteroposterior view.

(1) Marginal Polyspondylitis

This is the condition usually referred to as osteoarthritis of the spine. The essential features are clinically a pain in some part of the back for which all other causes have been excluded, and radiographically "lipping" of the vertebral bodies at or near the site complained of. American authors usually call it hypertrophic spondylitis, on the assumption that the pathological changes are comparable with those of osteoarthritis of the peripheral joints, although the intervertebral discs and cartilages with their surrounding ligaments are not strictly comparable, in any sense, with the freely

movable, synovial, diarthrodial joints in which osteoarthritis has usually been studied Nevertheless, this condition is incomparably the commonest type (Figs 154 and 155)

Shore (1935 *b*) has written on the condition and recorded his observations of dried macerated bones The following observations are taken from his paper:



FIG 155

A good example of polyspondylitis, with what appears to be osteoarthritis of the apophyseal joint of the fourth and fifth lumbar vertebræ on the right side This picture has considerable value as it shows clearly the apophyseal joints in the lumbar spine Some people regard the appearance round the fourth right lumbar joint as a congenital fault This, however, seems to be unlikely

Osteophytes arise from the anterior and lateral aspects of the vertebral bodies, not from the posterior or spinal aspect They are broader at the base and taper off at the apex and do not spread over the cartilaginous surfaces of the bodies They may span an inter vertebral interval Bizarre shapes occur if adjacent osteophytes make contact. They are not formed on a single vertebra but are spread over a group of vertebræ.

The osteophytes in the spine are bony substitutes for ligaments, whereas the osteophytes of the synovial joints are cartilage-capped chondrosteophytes growing from an articular margin Shore identi-

fies polyspondylitis with Lawford Knagg's *spondylitis osteoarthritica*. Although Knagg's description gives no finality to this conclusion, it is fairly clear that this is so.

These osteophytes are separated from the outer edge of the ring epiphysis by a groove, the "outer epiphyseal groove." The sheath of the intervertebral disc is attached to this outer epiphyseal groove The anterior and posterior longitudinal ligaments have superficial fibres which cover the length of several vertebræ, but the deep fibres are short and firmly attached to the edges of two vertebral bodies Here it is that the osteophytes arise and not from the bodies themselves As these two ligamentous layers can be dissected away from one another, it is evident that the deep fibres are a separate series of short ligaments and not an inherent part of the common ligament.

The maximum osteophyte incidence lies at cervical vertebra 4, thoracic 8 and 9 and lumbar 3 and 4. Humphry, in *The Human Skeleton*, found that the vertebral column is arranged in three alternating anteroposterior curves and that the junction points of these curves lie in the same vertical line with the line of gravity of the head and of the heads of the femora. These junction points are shown by Shore to correspond with the point of minimum incidence of osteophytes. He also shows that the maximum incidence of osteophytes occurs at the zenith of the curves, and concludes that here the vertebræ are more prone to slide and rotate on each other He gives fairly satisfactory proof that this movement does occur at the site of osteophytic formation.

The suggestion is that the vertebræ on the "plumb-line," usually called anticlinal vertebræ, are held firmly in place by the direct strain which they take. Faulty posture, therefore, as also deviations in the spinal column, could, on this assumption, easily lead to the appearance of osteophytes, and it is well known that this occurs.

Degeneration of the intervertebral discs.—The whole question of the nutrition of the intervertebral discs needs investigation. As the cancellous marrow-spaces of the vertebral bodies are closed by the cartilage end-plates, it is imagined that lymph perfuses through them to the discs. They have no known blood supply.

These points have to be considered in connection with Beadle's [illegible] of the discs commences after the fourth [illegible] idence comes next to that of [illegible] loes not show gross arteriosclerosis or hyperpiesia as one of its outstanding features, although the age incidence naturally would presuppose the occasional appearance of vessel calcification in X-ray films.

Whatever may be the explanation of these observations, authors are generally agreed that degeneration of the intervertebral discs and loss of turgescence in the nucleus pulposus are often precursors of polyspondylitis. This degeneration leads to fibrosis and loss of joint space (Figs. 156 and 157).

Osteophytes have been produced experimentally by allowing a portion of the nucleus pulposus to escape after puncture of the discs (Keyes and Compere) As turgescent nuclei are said to constitute



Fig 156

Lumbar spine showing unilateral loss of joint space with sclerosis in the bone round it There is a mild degree of scoliosis and it may well be that the lesion is due to this Note that there is a congenital fault in the fifth lumbar vertebra, but no evidence of polyspondylitis



Fig 157

Another example of loss of joint space, this time between the fifth lumbar vertebra and the sacrum, again probably due to spinal deviation Note how the transverse process on the left side has apparently thinned and tapered The osteophytic reaction appears below this

one-fourth of the height of the vertebral column, this feature may account for the apparent loss of height in some of these patients.

The loss of turgescence may lead to greater stress on the intervertebral discs; Shore gives some good illustrations of bulging of the discs with osteophytic formation in the short ligaments over the bulge The loss of space between two vertebræ, as shown by the X-ray films, is not a common finding. When it does occur, however, it is quite definite.

Age incidence of osteophytes.—Schmorl and Junghanns examined 10,000 spines at necropsy They found no osteophytes up to 20 years of age, 11 per cent. between the ages of 20 and 30, 36 *per cent*. between 30 and 40, 78 per cent between 40 and 50, and 93 *per cent* between 50 and 60 years This is a clear indication that the mere passage of years may produce osteophytes.

Distribution of osteophytes in the spine.—Shore has carefully tabulated his findings as to the incidence of osteophytes in the different parts of the spines which he examined He describes three "outcrops" The cervical outcrop occurred at the level of cervical vertebra 4, the thoracic at thoracic 7–10, and the lumbar at lumbar 3–4. He correlates these outcrops with Humphry's three alternating curves and finds that each corresponds with the zenith of one of these curves This leaves the minimum incidence at or about the anticlinical vertebræ. Clinical evidence on this point is given below.

(2) Osteoarthritis of the Apophyseal (or posterior spinal) Articulations

So far reference has been made only to the vertebral bodies and to the intervertebral discs and their ligaments, but it will be recalled that each vertebra has a dorsal arch. This arch provides a superior articular process and an inferior articular process to connect with similar processes of a vertebra above and below. These are all movable synovial joints. Other synovial joints in the spine are the *costovertebral, costotransverse, atlanto-occipital* and anterior atlanto-axial joints.

Shore (1935 *a*) has written on these joints, too, in a helpful manner. He records that Robert Adams of Dublin in 1857 wrote a book on chronic rheumatic arthritis in which he described *osteoarthritis in* these joints. The following observations are taken from Shore's paper.

His work was done mostly from macerated bones, but a sufficiency of soft tissue was supplied from the post-mortem room to enable him to reach certain conclusions. These conclusions—naturally not final ones—concern three aspects of the problem. They deal with the causes of osteoarthritis in these posterior joints, the anatomical side of the problem and the distribution of these lesions in the spine With regard to the causes of osteoarthritis, it is clearly shown that in a condition like scoliosis, in which pressure is produced on one side of the spine—that is to say, in the concavity of the scoliosis—osteoarthritis develops in the joints of that side and not on the other. In cases in which a great disturbance is produced, such as might be



Fig 158

Lateral view of cervical spine, showing osteo-arthritic change in the posterior spinal joints



Fig 159

Osteoarthritis of a costovertebral joint—thoracic spine

caused by collapse of a vertebral body, the same result is shown. Shore concludes that osteoarthritis, here as elsewhere, might be held to represent an effect of wear and tear. He thinks that central degeneration of articular cartilage is the starting-point of the chain of events which has osteoarthritis at its other end.

An important observation in this connection was made by Timbrell Fisher He erased the central part of one articular cartilage of a joint in a living animal, and the results included degeneration of a corresponding area of the opposite cartilage and the growth of heavy articular osteophytes. This observation is referred to elsewhere.

Shore concludes that failure of cartilage contact in any place would lead to degeneration opposite to it. It is assumed that cartilage loss centrally from any cause is supplemented by peripheral growth in an attempt to restore the normal amount and it is concluded that growth of cartilage, with its scaffolding of bone; constitutes the characteristic of the disease, and that this takes place at the most vascular region of the bone, the periphery.

Although this aspect of the problem is given the most prominent place, it is not suggested that other factors, such as infection, disordered metabolism, or disorders of internal secretion, do not have their own effect.

With regard to the distribution of the lesions in the spine, Shore outlines three main "outcrops" (Figs. 158–161) His first main outcrop runs from the seventh cervical to the first thoracic vertebra, the second, which is not nearly so well defined, runs from the second to the fifth thoracic vertebra, and the third outcrop starts at the second lumbar and is most marked in the second, third and fourth lumbar vertebræ If this is compared with the incidence of what Shore has called polyspondylitis, it will be noticed that the maximum incidence in that case lies between the fourth and fifth cervical, the eighth and ninth thoracic and the third and fifth lumbar vertebræ This is an important observation, for it shows that, whereas there is a difference between the incidence of polyspondylitis in the cervical and thoracic vertebræ, there is very little difference in the lumbar vertebræ.

The last portion of Shore's paper deals with osteoarthritis of the anterior atlanto-axial joint. From his observations it appears

intervertebral joints except those of the lumbar region. This does not accord with clinical experience.

These papers of Shore's have been quoted at some length because no others have been found which deal with the subject from an anatomical and pathological point of view.



FIG 160

Osteoarthritis of an apophyseal joint in the lumbar spine It is a likely diagnosis but not certain, as this may be a form of congenital abnormality (Compare with Fig 155)



FIG 161

Oblique view of the lumbar spine in order to show very early osteoarthritis of the apophyseal joints

The Symptoms of Osteoarthritis of the Spine

The common symptom of osteoarthritis of the spine is pain in some portion of the back. C[illegible]
the commonest. Spe[illegible]
right to say that in [illegible]
patients would complain of pain in the lumbar region, 3 of pain in the cervical region and 1 of pain in the thoracic region. The pain has a tendency to radiate and the cervical pain *tends to go down the arms*, the thoracic pain round the thorax and the lumbar pain down the legs. Comparatively few cases of osteoarthritis of the spine show this radiation of pain, but when they do so it may be of a very severe nature. This contrasts very sharply with the symptoms found in ankylosing spondylitis, in which radiation of pain round the body or down the limbs is a very common finding. Nevertheless, because radiation is uncommon in osteoarthritis, the possibility of its occurrence must not be forgotten.

Details of the Radiation of Pain

It is possible occasionally to obtain some information from a detailed study of the pain and its radiation.

The cervical spine—The site of radiation here is fairly constant The pain goes down over the top of the shoulder to about the level of the insertion of the deltoid muscle, and here it usually stops This is an uncommon spread for pain in angina pectoris. A local meningitis sometimes occurs over the root area of the fourth and fifth cervical vertebræ and this may give rise to such radiation. Apart from an *apical pleurisy, which occasionally* imitates it, these are the only [illegible] ordinarily have to be differentiated.
[illegible] er, show this pain fairly commonly.
[illegible] algia of various muscles, rheumatoid arthritis of the shoulder joint may all show it.

The thoracic spine—Radiation round the thoracic wall is a more difficult p[illegible]
from any
radiation
most care
be requir[illegible]
commonly the pain goes round the ribs at the level of the thorac[illegible] vertebræ 7–10 *and is often felt in the epigastrium and regarded as a* sign of indigestion

The lumbar spine.—The radiation of pain from osteoarthritis of the lumbar spine has some unusual features. Characteristic sciatic pain occurs but is relatively unusual. The pain is felt most often in the front of the thighs and on their lateral aspect. *Pain in this* region is unusual in other conditions; sciatic radiation is very much more common.

The *type of radiation mentioned above* always makes one suspicious. Apart from lesions in the hip girdle and *neuritis* of the external cutaneous nerve and of some of the small cutaneous nerves

passing over Poupart's ligament, there is no common lesion which produces this type of pain. The usual alternative is, of course, osteoarthritis of the hip, and as this is another locomotor disorder it is usually easy to separate them. Rarely pain from such a condition as renal calculus may be felt only in the groin, and occasionally this pain may be the result of fibrositic infiltrations in and round Poupart's ligament.

Physical Signs of Osteoarthritis of the Spine

Assuming that the general medical examination of a patient is negative, how are we to be led to suspect the presence of this condition? It seems quite evident that, whatever may be the site of the pain, the whole of the locomotor system must be carefully examined after the general medical examination is concluded

The cervical spine —Taking the cervical spine first, its mobility is tested with the examiner's one hand round the neck, holding the spine at various levels The other hand is placed on top of the head, which is moved gently sideways (Care must be taken not to allow the head *to rotate, as this movement takes place at the anterior atlanto-axial* joint) In this way lateral bending of the spine can be assessed and this is one of the first physical signs to be detected in osteoarthritis of the cervical spine. It must naturally not be expected that the mobility of the spine in a patient aged 60 years should be the same as that in a patient aged 30, and experience alone will enable one to judge whether or not a spine is stiff, taking the patient's age into consideration. Rather contrary to Shore's post mortem experience, osteoarthritis of the anterior atlanto-axial joint is seldom seen Clinical experience would have led one to doubt whether such a thing was a common event, as rotation of the head seldom is found to be limited Recently all cases of osteoarthritis of the spine, if the patients complained of severe pain radiating up to the head and if there was any limitation of rotation, have been carefully examined

indication of the integrity or otherwise of the costovertebral and costotransverse joints On the other hand it must be remembered always that the prime cause in most patients of a poor chest expansion lies in intrapulmonary pathology and not in disorders of the locomotor system.

The lumbar spine —The mobility of the lumbar spine is tested usually by making the patient touch his toes, with the knees straight, in the sitting and standing positions Provided that the hip joints are not affected and that there is no obvious lesion of the shoulder girdle, this gives an indication of the mobility of the lumbar spine, although congenitally short hamstrings will interfere with the test. In addition the patient is asked to lie on his face and, with the examiner's one hand on the anterosuperior spine and the other fixing

a rib, a twisting motion is given to the spine as a whole. The upper hand holding the rib is lowered gradually down the spine and the lateral mobility of the various segments is noted. While the patient is on his face the whole of the back is carefully palpated in order to find "nodules" in the muscles or ligaments, or even painful spots without palpable swelling. In one or two places the deep fascia can be palpated, and this too is a useful procedure. Lastly, it is usual for the patient to lie on his side and, the upper leg being allowed to hang over the edge of the couch, a twisting motion is given to the sacro-iliac joints and to the spine by pulling on the upper antero-superior spine, the upper shoulder in the meantime being held or pushed away from the operator This gives a good sacro-iliac twist. If all these movements are found to be full then the straight-leg raising test is applied. If this is also negative then it is concluded that the spine, so far as clinical tests can be relied upon, is mobile (see Chapter II—Clinical Examination).

Signs and symptoms in the cervical region.—Two groups of cases are said to occur in which signs are found The first group is usually referred to as Horner's syndrome; it includes narrowing of the palpebral fissure (due to interference with the unstriped muscle of the levator palpebræ superioris muscle), miosis and an apparent enophthalmos This is mentioned here because it is usually quoted but is seldom seen. It is likely to be uncommon, as it would presuppose some interference with the cervical sympathetic nerves, which pass from the cord at the level of the first and second thoracic vertebræ, and this is one of the least common sites for osteoarthritis.

The other group comprises fairly severe headache, going from the neck up the back of the head, sometimes as far as the vertex. This is often associated with areas of paræsthesia and patients sometimes say that they notice a different feeling in this part of the head when they are brushing their hair It is these cases which have been tested to find out whether or not the atlanto-axial joints are involved.

Unfortunately, of all the ills to which the spine is heir, probably osteoarthritis of the spine has the fewest physical signs.

The Clinical Findings correlated with the Anatomical and Pathological Descriptions

So far as age incidence is concerned, Schmorl's observations and general experience would seem to agree that the older a patient is the more likely he is to show osteophytic outgrowths from the vertebral margins

Site of Pain and Localisation of "Outcrops"

Table I summarises the position of the outcrops in the two conditions, marginal polyspondylitis and osteoarthritis of the spinal articulations, as described by Shore.

When we try to correlate the distribution of the pain as found clinically with the incidence of the lesions, it is a rather striking fact that polyspondylitis appears to occur most often in the two segments which have always seemed to be clinically the most affected This

question is dealt with above in the discussion of the radiation of cervical pain There is little doubt that pain or motor disturbance in the segments cervical 7 to

TABLE I

Site of Pain	*Polyspondylitis*	*Osteoarthritis of the Apophyseal Joints*
Upper back	Cervical 4 and 5	Cervical 7, thoracic 1
Middle back	Thoracic 7–10	Thoracic 2–5
Lower back	Lumbar 3–4	Lumbar 2–4

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So far as this factor is concerned, then, it must be said that the commoner sites of pain coincide with the "outcrops" of polyspondylitis and not with those of osteoarthritis of the spinal articulations

Limitation of movement —As is mentioned above, this sign is not found in all cases of osteoarthritis of the spine

The following gives an idea of the sites at which limitation of movement is most marked

The cervical spine —In this group cases fall into two categories The first and the commonest shows limitation of the whole cervical spine and the second shows limitation and 6 and not ion and it is

ment has always seemed to be more restricted in its lower half but again it must be remembered that osteoarthritis of the thoracic spinal articulations generally leads to lordosis, and that this throws more and unusual strain on the lower thoracic joints

Both these observations if they have any value, seem to suggest that the incidence of polyspondylitis is more in anatomical harmony with the symptoms and signs than is that of osteoarthritis of the spinal articulations

The lumbar spine —Osteoarthritis of this region, by far the commonest form, has no difference in anatomical incidence in either of its two main forms

Radiographical Appearances

Such evidence as has been obtained clinically is in favour of polyspondylitis as a cause of symptoms rather than osteoarthritis of the posterior joints, but it is clear that such evidence must be

subject to radiological confirmation, especially now that *modern* technique has advanced so far.

By means of skiagrams taken at suitable angles and with the proper technique, all the posterior joints of the spine can be visualised, but the appearances in osteoarthritis of the spinal joints are not the



Fig 162

Block vertebræ

This is a congenital anomaly which is frequently associated with osteoarthritis of the spine It represents a part of the Klippel-Feil syndrome.

same as are those of osteoarthritis of the limb joints Why this is so it is not possible to say, but a short table will show the differences (see Table II).

It should be remarked that in rheumatoid arthritis of the posterior spinal joints loss of joint space combined with decalcification are two notable features. Possibly the continuous pressure on these joints accounts for the loss of joint space in both rheumatoid arthritis and osteoarthritis, in contrast to the conditions which obtain in limb joints. Oppenheimer regards the loss as due to upward displacement

of subjacent articular processes, but his explanation assumes fibrosis of the discs in all cases, a finding which cannot be confirmed

TABLE II

X-ray Findings	Osteoarthritis of Posterior Spinal Joints	Osteoarthritis of Limb Joints
Decalcification	None	None
Sclerosis	Very severe	Severe
Joint space	Loss	No loss
Osteophytes	Not often present	Very often present
Loose bodies	Not seen	Often present

Certain other radiographical findings are also commonly encountered. Narrowing of the intervertebral spaces, mostly occurring in the older age-groups, is often associated with osteophytic formation. Horwitz noticed narrowing of the intervertebral foramina in the cervical region when the posterior part of the disc was lost and cervical lordosis was a feature, and, contrary to the view generally held, found posterior lipping of adjacent vertebral bodies, this lipping encroached on to the lumen of the intervertebral foramina anteriorly.

Comroe recommends the use of oblique views (45°) in order to demonstrate the size and shape of the intervertebral foramina in the cervical region. The demonstration of the size and shape of these foramina is mentioned fairly frequently in American literature and it is quite possible that this may be a line of advance in the future.

At the present time it is not possible to give any estimate of the relative frequency with which the X-ray films show polyspondylitis and osteoarthritis of the synovial joints, respectively. As an expression of opinion only, it seems likely that the X-ray films show polyspondylitis far more frequently. The reasons for this are not simple. One is that special films in order to demonstrate the synovial joints are not often asked for. The second is that, even if they are requested, it takes a great deal of skill and time to produce good films of the synovial joints. The third is that, even when the joints are visualised the interpretation of the films is often in doubt. This confusion I have tried to remedy by giving my own experience.

With regard to narrowing of the intervertebral spaces this is often shown on the X-ray films, but some observers fail to note it.

Summary and Conclusions

Anatomical evidence has been produced to show that osteophytic formation occurs in the short intervertebral ligaments and that this lesion has a certain incidence in the spine. Osteoarthritis of the apophyseal joints and its incidence is also discussed.

Clinical evidence is adduced which suggests that polyspondylitis does produce symptoms although some workers maintain that it does not (Gordon 1938). The symptoms of osteoarthritis of the spine are described together with the physical signs. An attempt is made to

correlate the clinical and anatomical findings The radiographical viewpoint is considered and its difficulties are mentioned.

Separation of the two main forms of osteoarthritis of the spine may lead to modifications in treatment

Treatment of Osteoarthritis of the Spine

Focal sepsis plays little part in this syndrome but *constipation* is often a troublesome feature and should be remedied. In all cases where the lumbar spine is affected, a careful rectal examination should be made in males, and a report from a gynæcologist should be obtained in females.

The treatment of *arteriosclerosis* and *obesity* should be undertaken when necessary The question of *posture* will be discussed later.

The Stage of Active Advance

On some occasions the condition comes into a stage of active advance and progresses rapidly. It becomes necessary to use unusual methods of treatment to cut short this stage T.A B. injections are sometimes successful, but there is no doubt they upset elderly patients a good deal. In view of this, injections of sterile milk may be substituted and occasionally have a very good effect, though the mechanism by which they operate is not understood. Injections of Aolan (Herts Pharmaceutical Ltd.) are useful One c.c. is given intradermally weekly, and the dose is increased by one c c. each week. If given very slowly as much as four to five c.c. can be given at a time The patient should be kept at partial rest until the acute stage is over. Physical therapy is essential at this stage

Acute spread of osteoarthritis is occasionally seen, the trouble spreading from the spine and involving peripheral joints quite suddenly, especially in old people For instance, in a male aged 80, with osteoarthritis of the apophyseal joint of L4–5 of many years' standing, pain and swelling suddenly developed in the carpal joints of both hands, in the tarsal joints of one foot, and in one elbow The successful treatment of such a condition depends on careful history-taking and examination In this case, it turned out that for several months a state of sub-nutrition had existed. The man's wife had died about eight months previously and he had been unable to cope with the worries of housekeeping and shopping, so that gradually he *had suffered from partial starvation With his gradually increasing* pain he attended a physiotherapist, who prescribed whole body radiant-heat baths three times a week. This added dehydration to his previous nutritional difficulties with a consequent spread of his trouble Two weeks in bed on a high-protein, high-vitamin diet, with cessation of his bath treatments, led to a complete amelioration of his condition, and the peripheral joints came into a state of resolution and eventually returned to normal To-day (five years later) he is well and free from pain. This is not uncommon, although naturally the circumstances vary in each case It is in this type of case that vitamins seem to be valuable

The *aim of treatment* in osteoarthritis of the spine is twofold, the *maintenance of mobility* and the *relief of pain*.

Much weight-bearing exercise makes these patients worse, but

muscles relaxed *Similar movements* have already been described in discussing diagnosis and in describing clinical examination, but will be briefly recapitulated here for convenience

Routine Movements in Treatment

(1) With the *cervical spine* held between the palm of the left hand and the thumb, and with the patient lying, *sideways movement* is imparted to the head by the right hand in both directions This must be done very gently and very carefully The head should then be rotated fully in both directions Flexion and extension of the head can be carried out with the patient on his side These movements should be repeated several times in each direction They are not so effective if carried out with the patient sitting, as the weight of the head tends to lead to muscle spasm

(2) *With the patient lying prone* and standing on the left of the couch, the ribs are fixed on the right side at various levels near the spine, a twisting movement being imparted to the spine by raising

hand The two hands
should be used The
Standing on the right
the other side The

twist is imparted to the spine at all levels, the hand which fixes the ribs travelling up and down the spine

(3) *The pelvic twist*—With the patient lying on his right side, the upper leg is allowed to dangle over the edge of the couch quite relaxed The underneath arm is gently pulled to give a twist to the spine Holding the upper shoulder back a twist is given to the pelvis and the spine by pulling the upper anterior superior spine towards you This is an extremely powerful leverage and must be done *very gently* As in previous movements a gentle rhythm should be acquired The movement is reversed for the opposite side

These movements are described because of their value, *but none should be undertaken lightly* If they are carried out twice a week, in a month mobility will usually be enhanced Pain, however, will not be relieved and may even increase

Very much the same type of movement is used for manipulation under anæsthesia and the conscious patient will benefit for much the same reasons Movements of this type are produced by powerful leverage, and are effective for this reason For the same reason they should not be used in *elderly patients* or in patients who show *advanced hypertrophic* changes with marked *osteophytic fringes*

Physical Therapy

Exercises have already been mentioned.

Heat and massage with passive movements do not produce th improvement that might be expected. The only cases in which the appear to be of real benefit are those where fibrositis is a marke feature. As these can usually be *picked out clinically, this is a usef* point to remember.

[illegible]

spondylitis. The treatment should be given weekly.

Diathermy is unexpectedly helpful. It seems to produce an appreciable effect but cases are seldom entirely relieved.

Suspension apparatus is very useful for this type of case. Eithe a Sayre's sling or a similar form of apparatus may be used. The suspension must be carried out very gradually, but once traction has *been commenced it must be continued for at least 15–20 minutes* with pauses for rest Time must be allowed for the muscles to relax for until this occurs the full benefit of the treatment will not be achieved.

If no suitable apparatus is to hand, the same effect may be produced by letting the patient lie supine with the head over the end of the couch Full traction can then be made on the head, and if necessary the patient's feet can be kept steady by a strap. This is a *very effective method for relieving pain.*

Faradism has a definite place but is most useful for osteoarthritis of the lumbar spinal joints Labile faradism is the treatment of choice *and the full effect will not be obtained unless the current is* gradually increased until fairly forcible contractions are observed. In cases where the cervical spine is involved it will generally be found that the treatment is too painful, if it is carried to the point where it is likely to be effective. If the dorsal area is affected little benefit will usually be observed.

Hydrotherapy.—If this can be obtained it is very useful. Free exercises, either assisted or unassisted, in the *warm pool* are un*doubtedly helpful, and suitable underwater douches* to the affected part seem to help These can either be carried out at the British Red Cross Clinic for Rheumatism in London, or at one of the spas Spa treatment is not as a *rule helpful for patients of this type,* unless obesity or hypertension are present. In that case, the spa is the treatment of choice.

Posture and Postural Defects

There are *two stages* in pre-human development which finally lead to the assumption of the erect position. The *first stage* is concerned with the conversion of the early quadruped into an upright tree-living type concerned with extensive use of the arms in swinging

This habit of life led to considerable changes in the forearms and *hands to allow grasping and,* because of the effect of gravity, greater

freedom in the attachment of the arms to the body This ended in the movement of circumabduction at the shoulder. At the same time, modifications in the hip joints occurred to allow full extension for the erect posture

To allow of forward vision, the head dropped forward and the cervical spine developed a forward curve Various other modifications occurred, but no marked lumbar lordosis developed The axis of the foot was transferred from the mid line to between the first and second metatarsals

At this stage, further tree life would have led to the posture shown to-day by the great apes so it seems reasonable to say that the pre-human stock took to the ground before their development made this difficult

The *second stage* was concerned with the evolution of ground-living habits They result from the effect of gravity on a body vertically supported on extended legs

This naturally freed the arms, already developed by a tree life It is thought that this *second era* began in the early Miocene and lasted to the present time The first era lasted from the Eocene to the early Miocene (both periods lasted about 30,000,000 years)

The example of a biped without a previous arboreal existence is the kangaroo, whose fore-limbs are mere appendages Morton (1926) quoted by Phelps and Kiphuth (1932), describes the earliest ground-living pre-human ancestors as being four feet high, of an agile habit. The arms did not present the characteristics of the anthropoid apes but were about the same length as the legs These pre humans were tailless and covered with hair but had no ischial pads The head was thrust forward, and the flexible spine was in a simple anteroposterior rounded curve The lumbar spine was flat although the thighs could be fully extended they were not normally held in that position The important contact of the feet was between the heel and the metatarsal bones

The freeing of the shoulder girdle led to its being dropped, with an apparent lengthening of the neck

The characteristic spinal curve was developed principally to allow
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lost its elasticity and became an organ of bipedal locomotion the heel gradually enlarged

The Maintenance of Balance

Certain muscles are constantly used in the maintenance of balance, others only on occasion For instance, when standing with the feet

close together, the muscles of the arms are used to throw the centre of gravity directly over the feet, but normally play no part.

All the trunk muscles of the axial skeleton are *constantly in use*. The ventral groups flex the spine, the dorsal groups extend it. The combined groups on one side of the body balance those on the other. Movement in the sacro-iliac joints is minimal. If the legs are of equal length and the floor is flat the pelvis is always parallel to the floor. If *one leg is raised on a small platform*, the right angle joint between the pelvis and spine remains fixed, but the spine curves convexly in a direction opposite to the lift, maintaining the line of gravity between the feet. The pelvis moves laterally to bring the weight equally on the two feet. The balance is held by the adductors of the raised leg and the abductors of the other leg. Stability is maintained by the balance of the muscles pulling upwards on the brim of the pelvis on one side (latissimus dorsi, erector spinæ, external oblique, internal oblique, quadratus lumborum) against the muscles pulling downwards on the brim on the other side (tensor fasciæ femoris, gluteus medius and minimus). The abductors of the thigh pull the pelvis down because the position of the leg is fixed. In considering alterations in posture in the lumbar region, these muscles must be considered.

These examples are given of the way in which posture and alterations in posture are maintained. Further information will be found in the chapters on Applied Anatomy and The Foot.

The Perfect Stance

The weight should be carried so that the weight *on the heel* is equal to that carried on the first and fifth metatarsal heads. *The thighs* should be held midway between internal and external rotation, the feet parallel and three to four inches apart. In this stance, the gastrocnemius easily controls the backward and forward sway of the body.

The *knees* are extended *but not hyperextended.*

The amount of *flexion in the hips* should be as slight as possible. As the lumbar spine is concave backwards, tension on the erector spinæ group will increase this curve. There must therefore *be good tone in the rectus abdominis.* A [illegible]
concavity will tend to straighte[illegible]

[illegible] rector
[illegible] ards

The perfect stance gives maximum stability with minimum active muscle contraction.

A consideration of the factors mentioned here will allow the more obvious postural defects to be noted. The most frequent postural [illegible]

Other common postural defects are [illegible] *posture of the head,* and that due to a *protuberant* abdomen.

Having decided that a significant postural defect is present, it is the physician's duty to consult an orthopædist with regard to its treatment

In conclusion it would be right to say that osteoarthritis of the *spine is a syndrome that varies in frequency with the years of a man's* life With an accurate diagnosis and good treatment the outlook is excellent so far as mobility is concerned, but the alleviation of pain is undoubtedly a difficult problem In cases where the measures mentioned have been tried and found wanting, two additional measures remain.

The patient can be immobilised for a period in a *body plaster cast.* This measure may be successful where all else fails Should this also fail, the dorsal roots of the affected segments may be injected with procaine. This measure should be kept to the last, but it has proved very successful It can be usefully combined with suspension treatment. In those very rare cases which resist all treatment, and if the arthritic process is confined to only *one or two joints* and those in the dorsal spine, an arthrectomy will be curative

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CHAPTER XXIII

ÆTIOLOGY AND PATHOLOGY OF FIBROSITIS—DIAGNOSIS AND TREATMENT OF FIBROSITIS

FIBROSITIS (FIBROMYOSITIS, MUSCULAR RHEUMATISM)

FIBROSITIS is the term most commonly employed to designate pain which is located in the soft tissues of the trunk and limbs of which the causation is not obvious. It is characterised by

These points are sometimes palpable, in which case they are referred to as "fibrositic nodules."

Definition and Classification

Fibrositis is common in the British Isles, as it is in most of the other European countries. In America it has never been well recognised, and some recent monographs on rheumatic conditions have actually failed to mention it

Stockman, following Gowers, defined fibrositis as a "condition of chronic inflammation of the white fibrous tissue of the fascial aponeuroses, sheaths of muscles and nerves, ligaments, tendons, periosteum and subcutaneous tissues, occurring in all parts of the body, and giving rise to pain, aching, stiffness and other symptoms, the result of preceding general infections or local inflammations or injuries." It is now generally defined, less comprehensively, as a rheumatic disorder of the soft tissues, chiefly characterised by pain, which may be local, widespread or referred. It is usually classified according to the portion of the body which is principally affected The commoner types are therefore self-explanatory and include lumbago, pleurodynia, "rheumatic headache" and torticollis Sciatica may result from fibrositic pain being referred down the thigh and leg, whilst "brachial neuritis" may stand in the same relationship to an area of fibrositis in the neck or shoulder girdle

Buckley, writing in the *Encyclopædia of Medical Practice* (1937) classified fibrositis according to the tissue which he believed to be principally involved, and described: (1) "*Panniculitis,*" chronic fibrositis of the subcutaneous tissue or panniculus adiposus This is met with in its most characteri the loins and buttocks, and to the *rsitis,*" which may affect any of the the shoulder, elbow and knee joints. (3) "*Periarticular fibrositis,*" which affects the joint capsule, but not generally the synovium He then becomes regional, and concludes his classification by describing: (4) "*Fibrositis of Head and Neck,*" (5) "*Brachialgia,*" (6) "*Pectoral Fibrositis,*" (7)

"*Intercostal Fibrositis*," (8) "*Fibrositis of the Back*," (9) *Fibrositis of th*[e] *Plantar Fascia*" and (10) "*Fibrositis in other regions*" From this it will be seen that it is difficult to evolve a really satisfactory classification in the absence of further information regarding the ætiology of the condition

There are also epidemic forms, of which the best recognised is Bornholm Disease The characteristics of this are sudden onset after an incubation period of about 5 days, with some fever and acute pain in the region of the diaphragm, which is increased on deep breathing and which lasts 10–15 days Rolleston describes it as ' the counterpart, in front of the trunk, of lumbago ' It is believed to be due to a virus infection Less well recognised epidemics of stiff neck and fibrositis of the shoulder girdle have been recorded since 1935 Four outbreaks of these syndromes were studied in England during the winter of 1940–41, and the clinical, epidemiological and experimental findings were fully reported by Beeson and McNair Scott (1942) It will probably be found ultimately that epidemics of this sort are not uncommon, but pass unrecognised as such, owing to the congestion of our modern environment

Ætiology and Pathology

The ætiology and pathology of fibrositis are not fully elucidated It seems probable however, in a disorder in which pain is the leading symptom, that differing causes may operate in different cases Certain factors are intimately connected with the onset of many cases of fibrositis Whether these factors are actually causative, or merely act as the precipitating factors, is perhaps a less academic question than has sometimes been thought, since their further study would undoubtedly advance our knowledge of the chronic rheumatic diseases

The chief ætiological factors are as follows (i) *Focal sepsis* (ii) *Trauma*, (iii) *Strain*, (iv) *Cold and wet*, (v) *Gout* (vi) *Heredity and constitution*, (vii) *Relation to other rheumatic diseases* and (viii) *Psycho-neurotic disorder* Some of these may be very briefly commented upon in the light of present knowledge

(I) Infection

This idea originated with Sir William Gowers who believed the process of fibrositis to be of an inflammatory nature Stockman (1920) took the conception further with his description of fibrous nodules which he had excised from patients suffering with fibrositis and which he also considered to be the result of infection With regard to the organisms which he believed to be responsible however, he was less specific, since he stated that careful search had failed to reveal any micro-organisms in the inflamed tissue, and cultures had always remained sterile He summarised his final position as follows "In view of our present knowledge it seems at least likely that the local fibroses are due to small colonies of microbes invading the tissues and causing a reaction which comparatively rapidly destroys the invaders"

Willcox (1921), after the last war, re-enunciated the theory of "focal sepsis" whereby the inflammatory nature of the disorder was maintained, and the absence of micro-organisms at the site of the pain was explained Belief in the universal application of this hypothesis has

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its entirety. He demonstrated that pain originating in such points, in addition to being felt locally, might be referred to any other region within the same neural segment. He

points experimentally by injecting n

saline into the deep tissues of nori

showed later that these trigger points frequently arise during the course of most of the infective fevers. Although in most cases these disappear as the patient recovers, in a definite proportion of cases they persist, unknown to the patient, and can be reactivated by further infections of any sort. He thought that trigger points which originate during some acute illness—such as influenza—and which are reactivated several times, often by coryza, might become the basis for chronic fibrositis at a future period.

(2) Trauma

This has always been recognised as being a potent factor in the ætiology of fibrositis, and that view has received ample confirmation during the recent war as the result of the enormously increased degree of mechanisation in the army. Certain forms of fibrositis came to be recognised as being occupational; for instance the type affecting the forearm and shoulder of the A A gun-layer, the torticollis of the Sherman tank driver and the lumbago of the bulldozer operators. Trauma in this connection need not be confined to damage suffered by the soft tissues from the outside, but can include the effects of postural and other strains upon them The effect of trauma—either direct or as the result of prolonged or repeated microtraumata—is presumably to establish small somatic lesions which, when they become sufficiently definite, will constitute trigger points, which will themselves give rise to pain, and from which pain may be referred.

(3) Cold and Wet

Both cold and wet have always been associated in the popular mind with chronic rheumatism, but little serious investigation has been directed towards their *modus operandi.*

Peterson and certain German authors have accumulated much meteorological data and have correlated it with various biochemical

definitely appear

war has amply con-

be provoked in an

apparently fit subject by the direct action of cold It is probable that, as individuals vary in their apparent sensitivity to the effects of cold,

the question of "conditioning" to low temperature is of greater importance in the production of a rheumatic response than the absolute temperature to which such a body is exposed It may be in this direction that the clue to the "rheumatic constitution" lies The general lowering in the temperature of the body which results from the effect of a cold environment, and which will be increased if the skin or clothes are damp, is not the only aspect of cold which needs be considered The effect of local cold generally as a draught impingeing upon some uncovered portion of the body, is also recognised as an apparently causative factor in some cases of fibrositis It is thought now that "weather sensitivity" in the fibrositic patient is dependent upon the "cold fronts" which are known to meteorologists to precede major changes in weather During these periods the temperature changes are often very considerably greater than is generally realised

(4) Relation to other Rheumatic Diseases

According to Thomson and Gordon (1926) "practically all people who suffer from gout suffer from fibrositis" A form of fibrositis is also described which is the only evidence of an underlying 'gouty diathesis," and this is well documented, although its recognition must rest, in the absence of a strong family history, on a raised level of uric acid in the blood and the test of therapeutic success with colchicine or atophan

A more interesting association is between acute rheumatic fever and fibrositis. Copeman (1944) and others have published observations which show that fibrositis can undoubtedly be left as a legacy of rheumatic fever, and that it cannot subsequently be distinguished from fibrositis of other causation It has already been observed that [illegible] the acute [illegible] sted that [illegible] n specific in type

(5) Psychoneurotic Disorder

Of recent years it has become fashionable following the lead of Halliday (1937), to regard fibrositis as being a psychosomatic disorder This observer regards it as the external manifestation of inner tension or as a general symbolic representation of inner frustration This view has proved attractive to many physicians who, in the relative absence of objective physical signs have been unable to see any rational approach to organic therapy That emotion may result in spasm and probably therefore in vasomotor ischæmia, is agreed, and where this occurs the affected tissues may be more than normally open to the direct effects of environmental influences It would seem, however, that this view of the ætiology of fibrositis must have considerable limitations Flind and Barber (1945) recorded in considerable detail a series of 42 R A F patients who complained of generalised body pains They concluded on the evidence that in all

of these the disability was essentially psychogenic. Post-war American literature also stresses this trend of thought.

Copeman and Pugh (1945) carried out a personality assessment on a series of 100 patients under treatment by them for fibrositis and were unable to assign a causative rôle to any mental factor in the cases seen although fatigue and anxiety connected with battle were frequently met with and appeared to be connected with the progress of the disease An assessment was made of the personality types of an unselected series of fibrositic patients, from which it seemed clear that no one personality type was predominant amongst them. Elaboration and prolongation of symptoms was generally seen as an escape mechanism in patients in whom evidence of an hysterical overlay was found, however, and the response to treatment in these cases was correspondingly less favourable than in more stable personalities. Their conclusions may be quoted, "It is considered that there is no correlation between the onset of true fibrositis and neurosis The neurotic is, however, apt to exaggerate the importance of minor strain and rheumatic lesions, and psychogenic lesions are frequently responsible for the amount of incapacity resulting from the symptoms and the undue prolongation of the disability after the acute phase of the illness has passed."

Pathology and Morbid Anatomy

Fibrositis is not in the usual sense a generalised disease, although the pain may be felt in almost any part of the body. This pain, however, centres in and radiates from localised tender trigger points, which if they are palpable are often termed fibrositic nodules The pathology and morbid anatomy of fibrositis must, therefore centre around the nature of these trigger points or nodules

Stockman was the first to attempt to elucidate their pathological basis and he concluded that the essential pathological changes in fibrositis are confined to the white fibrous tissue in connection with the muscles, joints and peripheral nerves, and that the lesion consists in inflammatory hyperplasia of the connective tissue in larger or smaller patches, and that this differs from normal fibrous tissue in the

other explanations were sought

Comroe in his volume on *Arthritis and Allied Conditions* (1944) wrote that "the ætiology is unknown," and that "there are no convincing pathological studies in this disease"

In 1944, Elliott suggested that the pain in fibrositis is the effect of localised involuntary muscle spasm arising reflexly from lesions elsewhere. He considered that the "nodules" which are commonly felt in fibrositis at the principal sites of pain may, in reality, be small groups of muscle fibres which are in spasm owing to irritation of the nerve roots supplying them, and pointed out that the success of local measures designed to relieve pain, such as the application of heat, or

injections of novocaine, does not necessarily preclude the presence of a central lesion of the nerve roots or spinal columns He does not, however, seek to shut the door entirely on fibrositis as a clinical entity by "the facile generalisation that muscle tenderness is always due to spasm of skeletal muscles "

Copeman and Ackerman (1944) whilst agreeing that muscle spasm may play a part in the symptomatology of fibrositis consider that this is, in most cases, secondary to an organic focus of irritation which is

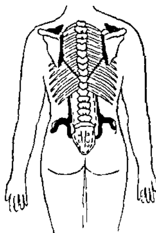


FIG 163

85 per cent of fibrositic 'trigger points' in the back are located within the regions marked in black

(Copeman and Ackerman)
By permission of the Editors of Quarterly Journal of Medicine

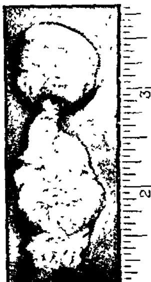


FIG 164

A large fatty hernia of the pedunculated type This specimen was constituting an exquisitely tender palpable 'fibrositic nodule' in the lumbar region *(Courtesy of Dr C B Heald)*

generally situated in the fibro-fatty tissues which they show to be adjacent to the muscles in certain well-defined regions of the body —those regions in which trigger points most frequently occur In a series of biopsies they found the seat of pain to lie in discrete œdematous fat lobules which were invested by a fibrous membrane The fact that this was non distensible had apparently led to an increase of tension within the lobules and in some cases in which this membrane was deficient actual herniation of the lobule had occurred This fat hernia may if it does not get rapidly reduced as the result of muscular action or by massage become partially strangulated This leads to it becoming even more œdematous or hæmorrhagic Adhesions form between it and the surrounding structures at which stage it becomes irreducible, and may ultimately actually become ped-

unculated, and the lesion becomes chronic. More recently Copeman and Pugh (1945) have published observations which suggest that this non-inflammatory œdema which appears to be the basis of fibrositis is the result of osmotic changes induced directly by external factors, such as cold and trauma They were able to relieve the pain of fibrositis in a number of cases, generally temporarily, by experimental dehydration of the tissue cells. By this procedure they considered that they had reversed the original causative process of local intracellular shift of body fluid. From their results it would appear that this local alteration in fluid distribution, which as the result of increased tissue tension leads to pain, could be influenced directly by what are commonly believed to be merely precipitating factors (cold and trauma) Rationale is thus afforded for the well attested phenomenon of "weather sensitivity" which has been referred to above They also suggest that the changes involved become gradually less easily reversible, and so eventually the disorder becomes chronic.

To Summarise

It seems improbable that fibrositis can claim to be a really "pedigree" disease There are probably several types, each with its own pathology which may none the less be causative of the same symptoms. These will range from gross trauma to the microtraumatic lesions of faulty occupation or posture, which may as the result of fibrosis constitute the fibrous nodules of Stockman; the localised regions of muscle spasm described by Elliott, where there is root irritation for any reason; the non-inflammatory œdematous areas, with or without fibro-fatty herniation, as described by Copeman and Ackerman, to the non-localised muscular pain at present believed to result from psychoneurosis

The Clinical Aspect

Fibrositis, although a common complaint in this country, is rare in the earlier decades of life, and is somewhat more common in the male than in the female. Occupation is an important factor, in particular in its relationship to environment Van Breemen has shown it to be twice as common in outdoor workers as in persons in sheltered work Many occupations are believed to produce a characteristic fibrositis syndrome, amongst these may be mentioned the lumbago of gardeners and miners, the torticollis which affected the drivers of Sherman tanks in the war, "shovel shoulder" which has been described as occurring amongst navvies, and the painful forearms of the bus driver

There is no doubt that even to-day there is a tendency to diagnose as fibrositis any pain for which the reason is not immediately obvious More detailed examination will in many cases reveal an underlying cause such as arthritis, spondylitis, neoplasm, or some general disorder of which fitting muscular pain may be an accompaniment, for example, leukæmia, th[illegible] deficiency diseases More obscure conditions of [illegible] ist also be borne in mind, and [illegible] sitis

Certain regions of the body are more liable than others to be affected by fibrositis, and the more common syndromes may be briefly reviewed.

Torticollis

The clavicular head of the sternomastoid muscles the trapezius, and the occipital muscles are frequently affected The condition is often acute, and unlike other forms of fibrositis is commonly seen in late childhood and adolescence On careful palpation small but exquisitely tender regions or nodules may be found on the affected side and injection of these may give immediate relief If untreated, the condition usually subsides after three to four days, although there is a tendency to relapse

In adults the chronic form is more common and the onset is usually insidious In these cases the pain is inclined to radiate upwards into the occipital region producing the ' rheumatic headache " which may last for months or even years after the torticollis has disappeared This syndrome must be differentiated from torticollis of reflex origin—trauma, cervical caries and otitis media being the commonest causes

Brachial Fibrositis

The soft tissues around the shoulder girdle are not infrequently the seat of fibrositis, the *subacromial bursa* often sharing in the process

The acute form, which was common in the army is generally related to chill at the onset The condition is usually unilateral, and intense pain is produced by muscular contraction which results in the immobilisation of the joint by spasm This immobilisation will in some cases persist after the pain has disappeared, presumably owing to adhesions having formed within the folds of the capsule, resulting in what the Americans term the "frozen shoulder" This syndrome will yield to diathermy followed by active assisted movements in the early stages, but the later stages will yield to nothing but manipulation

Brachial fibrositis must be differentiated from *brachial neuritis*, since the indications for treatment are different In the latter syndrome the pain is less localised and will affect the nerve trunks, radiating down these and often producing neurological symptoms in the fingers such as parasthesia, or alteration in sensation If this is due to a prolapse of a cervical intervertebral disc the pain may often be influenced by pressing on the patient's head, or movement of the cervical spine In every case spondylitis, cervical caries and referred pain from cardiac disorder must be borne in mind (see Chapter XXXI)

Pleurodynia

Fibrositis will not infrequently affect the chest wall localising in or around the intercostal muscles of one side, but sometimes involving also the pectoral and serratus muscles. The pain often comes on suddenly and may be exceedingly intense, and in such cases a cardiac lesion may be, incorrectly diagnosed Muscular movement, and in particular coughing or sneezing will intensify the pain It

can be differentiated from pleurisy by the fact that the pain is usually more localised and more severe, and that the patient's temperature and general condition is unaffected; whilst there are, of course, no physical signs. In the early stages of herpes zoster a differential diagnosis is often impossible.

Lumbago

Severe fibrositic pain may occur in the lumbar or gluteal regions and may be of acute or insidious onset. The precipitating cause is often severe exertion or chill, in other cases it is obscure, and may even come on whilst the patient is in bed. Copeman and Ackerman (1944) mapped the sites of the "trigger points," which are characteristic of this condition, and produced a "pain pattern" which was found to outline the outer border of the erector spinæ muscles, a region two inches deep along the border of the iliac crests, and the sacro-iliac joints Biopsy at these tender points showed them often to consist in small herniations of the deep fat lobules, which are located in these regions, through their investing fibrous capsule Removal or injection of these proved curative. There is generally considerable spasm of the muscle
likely that this may, in its turn,
in the lumbar or gluteal region
back of the leg, producing the fibrositic form of sciatica

The differential diagnosis of lumbar pain will include localised tuberculous or other infection of the bones of the spine or pelvis, arthritis, trauma, renal disease, pelvic infection, sacro-iliac strain and —never to be forgotten—malignant disease.

Neuritis

The conception of an inflammatory process of "rheumatic" origin which will affect white fibrous tissues selectively is generally held to explain the syndrome known as interstitial neuritis This is visualised as an acute or chronic inflammation of the fibrous supporting tissue which binds together the separate nerve fibres into nerve bundles As the result of this the fibres are believed to be compressed, with resulting motor and sensory loss in the territory they serve, and pain which is often referred to their ending There is also, generally, definite tenderness along the course of the affected nerves. Such a syndrome should not be assumed to be "rheumatic" unless chronic toxæmia resulting from arsenic, lead, alcohol, diabetes, or chronic focal infection has been excluded. Spinal irritation resulting from arthritis, caries, neoplasm, or prolapsed intervertebral disc must also be considered

Sciatica

This has been referred to above. As the result of recent investigation it would seem that a considerable number of cases of sciatica may be due to prolapse of an intervertebral disc. This diagnosis must, however, be made on positive neurological evidence.

There remains a proportion of cases of fibrositic origin which are amenable to treatment directed towards this underlying cause.

Panniculitis

There is a form of fibrositis known as panniculitis in which the fat of the panniculus adiposus becomes swollen and painful in certain regions. The patient complains generally of constant dull pain in the affected regions, with acute exacerbations. A characteristic sign of this affection is the peculiar *peau d'orange* effect produced on attempting to pick up the skin in the region of the pain.

The regions chiefly affected are the internal aspect of the knees, the shoulders, and the back of the neck. This latter site is often responsible for headaches due to referred pain. This condition occurs frequently in women who are within the menopausal zone, but is also seen in men who are "well covered." It is generally assumed that it is the fibrous tissue which is affected in this condition. Copeman and Ackerman believe, however, that the underlying mechanism of the pain is in a shift of extracellular body fluid into the fatty tissue cells in these regions, causing pressure on the nerve endings from the resulting distension. This condition can generally be differentiated from myxœdema in which condition "fibrositic" pains are also sometimes complained of.

The progress in this type of fibrositis is good, if adequate treatment is applied at an early stage.

Treatment

General Remarks.—The successful treatment of fibrositis can never be routine or mechanical. There are many methods which, properly applied often in conjunction, will be of use in certain cases. The art of proper selection of these remedies and cases constitutes the secret of successful treatment in this group of diseases. Many of these remedies are empirical although with advance in our understanding of the underlying pathological processes we often discern a rationale which was previously obscure. Certain of these methods have been traditional since the time when the Romans used the hot springs of Bath for the treatment of rheumatic diseases. These methods comprise the application of heat, sweating and rubbing. Since it can be assumed that these methods are productive of therapeutic benefit, it may be inquired whether any common factor or aim can be discerned in them.

It will be apparent that purging and sweating will eliminate both fluid and salt from the body, whilst rubbing presumably "disperses" something as does its modern equivalent, massage. Finally, heat, apart from its production of sweating, owing to its effect upon the circulation is sedative to pain and increases the venous and lymphatic drainage of the affected region.

If the pathology of certain cases of fibrositis, already described, in which the pain depends upon local increase in tissue tension due to an intracellular shift of body fluid is confirmed, it is just these

methods which would be required to increase the osmotic value of the extracellular fluid. A salt-free diet should also be of great advantage in perpetuating this desirable process, particularly if it were accompanied by an increased ingestion of water.

In those cases in which the pain may be primarily due to muscle spasm, the various traditional devices for the local application of heat, such as the heated flat-iron or bag of salt, become as rational in theory as they are comforting in practice

Rest—The advice generally given is to rest the victim of acute fibrositis in bed, and this is based on the belief that active inflammation is the cause of the pain. The painful reflex spasm induced by movement will tend of itself to immobilise the patient unless it be relieved, but if this can be achieved he will immediately be able to resume activity and, far from harm resulting, this happy state of affairs will often persist

The researches previously referred to suggest that the effusion which occurs in these cases is non-inflammatory, and that the pain results from the increase in the tension of the affected tissues. If this is so, our aim should be to disperse it by every means in our power, it is unnecessary and undesirable to wait, since adhesions may develop Such means may include locally applied heat, infiltration of the spastic muscles with local anæsthetic, in order that they may relax sufficiently to permit of natural movement, manipulation, and firm strapping Rest should, therefore, only be necessary where active treatment is not available.

Analgesic and other drugs—Analgesics are always indicated, both to relieve the pain directly and to aid in the relaxation of the defensive muscle spasm A combination of a centrally and a locally acting drug is the most successful

[illegible] and its

derivatives are seldom necessary in the non-articular group of rheumatic diseases, although the pain occasioned by an acute *lumbago* of sudden onset will sometimes merit it. In such circumstances, which amount to a medical emergency, it is best to employ it by injection in order to achieve a quick result, after which the other groups may be employed.

The *phenazone group* contains a number of preparations of which phenacetin (5–10 gr) and pyramidon (5 gr.) are the most commonly employed Antipyrine, owing to its unpleasant side effects, is now but seldom used Many proprietary anti-rheumatic drugs are of this group

The *barbiturates* are more sedative than analgesic, although in combination with locally acting drugs they are said to reinforce their action The most rapidly acting are Evipan and Pentothal (gr. 7½) then come Nembutal, Seconal and Soneryl (gr. 3); those whose effects take longest to appear, and which are, therefore, the most cumulative, are Phenobarbitone (gr. ½–1½) and Medinal (gr. 5–10). The *cinchophen* group, although originally introduced for the treat-

ment of chronic gout, has some place in the treatment of fibrositis in view of the fact that it appears to exercise an analgesic effect in certain cases in which there is no evidence of an underlying gouty background Atophan (gr 5–15) is the best-known member of this group It should never be given for longer than three days, in the normal dosage of gr 7½ t d s An interval of seven to ten days should then be allowed to elapse before this is repeated The opinion of Willcox was, however, that the modern use of drugs of this group is not justified in fibrositis if pain can be controlled by other means, in view of a considerable number of cases which have been reported as developing toxic jaundice associated with serious liver damage. The risks of this occurring will be minimised if sodium bicarbonate is given (gr 15) in half a tumbler of water at the same time, whilst the administration of glucose is thought to protect the liver against toxic action of this sort

The locally acting group of drugs is the *salicylate* family Amongst these aspirin takes pride of place, and should be given—15 gr four-hourly In smaller doses this may be continued whilst the patient is in the stage of recovery, although care must be taken that he does not get chilled, if he goes out of doors, on account of the diaphoresis which it produces Calcium aspirin has the advantage that it does not produce gastric intolerance, and that it is soluble in water and so may be given as a mixture It must be given in rather larger dosage than is ordinary aspirin if a comparable effect is to be produced Sodium salicylate although much used for the treatment of fibrositis, especially in hospital practice, is probably without effect and should not normally be used Phenylsalicylate (Salol) enjoyed a vogue some years ago in this group of diseases, often being combined with guaiacol carbonate (5 gr of each) Its action is that of an intestinal antiseptic, so that its effect in fibrositis is uncertain Tab Codein Co is a mixture of aspirin phenacetin and codein which combines the principle of combining a centrally and locally acting drug as enunciated above, and is extremely useful in fibrositis

Iodides —Cushney (1941) said "although the iodides have been more largely used in medicine than any of the other salts of the alkalis, their mode of action is still obscure Rheumatism in its various manifestations is often treated with iodides this is of little value in acute rheumatism and often fails in the chronic disease Any beneficial effect produced by this group of drugs is likely to be due to their effect upon the thyroid secretion When thyroid insufficiency is due to the absence of iodine, and if the gland cells are normal, both the iodides and iodine give good results The iodides have also been credited with promoting the absorption of effusions and the removal of hypertrophied fibrous connective tissue in the body Their efficiency in removing the syphilitic gumma was obviously the origin of their use for such purposes The justification for their use in the treatment of rheumatic fibrosis is however highly speculative." From what has been said it will be seen that the preference shown by many authorities for certain eclectic preparations or combinations of iodine and the iodides would appear to be without sound basis.

Sulphur.—Sulphur is itself pharmacologically inert, and a great portion of that swallowed escapes unchanged in the stools. Some of it, however, forms sulphides which cause irritation in the intestines increasing peristalsis, and so the fæcal output It may be this mild purgative action which leads to its old-established reputation as an

it was given in combination with guiacum under the popular name of "Chelsea Pensioner." (See chapter on Treatment of Rheumatoid Arthritis)

Thyroid extract.—In certain cases, particularly those associated with panniculitis or generalised obesity, or arising within a few years of the menopause, thyroid extract is sometimes of service. A quarter or half a grain (B.P.) may be given twice or three times a day before meals with a draught of water. The good effect is usually ascribed to loss of weight, but as the most potent factor in weight reduction brought about by thyroid medication is removal of fluid from the body by diuresis, it may be wondered whether it may not be the effect of the resulting decrease in fluid tension in the cells of the affected tissues which is the cause of the reduction in pain in these cases (see Chapter XXI)

Focal Sepsis

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to determine whether a tooth is vital or not, since a vital tooth is seldom found to be infected in this way. Radiology will yield this information only in cases where there is a root-filling, which can, of course, be visualised. Where definite apical infection can be established, extraction is indicated on general principles, but wholesale extraction is probably never justified in view of the shock, toxæmia and ultimate dissatisfaction which this measure generally induces, often fruitlessly, so far as the fibrositis is concerned. Where the sepsis is confined to the gums (pyorrhœa), extraction is to-day

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Tonsillectomy should be approached with caution and should be regarded almost as a major operation in adults past middle life Where infection of the tonsils is suspected but not proven, little is likely to be lost ultimately by treating them conservatively for a time by means of Mandl's paint or organic silver preparations, in

to maintain activity of the disease It is often, however, a sign of infected nasal sinuses, especially the antra A sulphanilamide spray or paint will be of value in streptococcal cases, in others dilute protargol In many cases it is wise to give routine instructions for the hygiene of this region The following is a sheet used in the Department of Chronic Rheumatic Diseases of the West London Hospital

1 Gargle with Lotio alkalinus or normal saline morning and night
2 Sniff an alkaline solution up both nostrils morning and night
3 Brush the teeth once a day at least
4 Breathe through the nose

It must be rare for the *sinuses* not to share in any generalised infection of the nasopharynx to some degree It is not necessary for there to be a profuse nasal discharge or polypoid formation for the sinuses to be the origin of toxic condition in the body It is always suggestive of sinus trouble if a redness and swelling is seen of the lateral pharyngeal columns of lymphoid tissue which lie behind the posterior pillars of the fauces Also if the posterior wall of the pharynx is red and glazed in appearance These conditions sometimes give rise to a swelling of the small glands in the posterior triangle of the neck This adenitis may in itself be the cause of "stiff neck, and this symptom should therefore give rise to suspicion of sinus more particularly antrum trouble The treatment of such sinuses will generally be surgical if the infection is definitely proved In doubtful cases however an aspiration followed by lavage with normal saline and culture of this fluid subsequently will often help to make the diagnosis

Palliative treatment will include nasal insufflations protein silver applications which should probably be applied by the displacement method however since in many cases they do not otherwise enter the sinuses. Short-wave diathermy is now much used but is principally of value in the more acute cases whilst vaccine therapy is of value in certain cases Palliative treatment should be tried in all cases other than acute ones prior to embarking on surgical procedures More recently sulphanilamide and its chemical colleagues and penicillin have also been added usefully to our armamentarium

Chronic non specific infection of the *prostate gland* appears as the result of army experience to be more common than was previously suspected and may well be suspected, when present, of acting as a

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Although the modern tendency has been for some years to discredit focal sepsis as an ætiological factor in the production of fibrositis, it remains probable that this mechanism is concerned in the production of certain cases Whether the mechanism be one of direct toxæmia with an unexplained selective action for the affected tissues, as Willcox believed, or whether it be allergic in nature, due to a slow sensitisation of the cells of the affected tissues to the specific antigen contained in the protein disintegration products of bacteria, as Lichwitz taught, is at the present juncture immaterial, since there is insufficient evidence on which to do more than guess intelligently. The point [illegible]

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Postnasal catarrh is a frequent finding in cases of rheumatism and may in some cases constitute a low-grade primary infection sufficient to maintain activity of the disease It is often however, a sign of infected nasal sinuses especially the antra A sulphanilamide spray or paint will be of value in streptococcal cases, in others dilute protargol In many cases it is wise to give routine instructions for the hygiene of this region The following is a sheet used in the Department of Chronic Rheumatic Diseases of the West London Hospital

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The *teeth* have long been suspect in such cases and radiography is rightly employed to determine whether root infection is present It is, however, not generally realised that the really important point is to determine whether a tooth is vital or not, since a vital tooth is seldom found to be infected in this way. Radiology will yield this information only in cases where there is a root-filling, which can, of course, be visualised Where definite apical infection can be established, extraction is indicated on general principles, but wholesale extraction is probably never justified in view of the shock, *toxæmia and ultimate dissatisfaction which* this measure generally induces, often fruitlessly, so far as the fibrositis is concerned Where the sepsis is confined to the gums (pyorrhœa), extraction is to-day

seldom necessary, since modern dental practice can generally be relied upon to abolish this

Tonsillectomy should be approached with caution and should be regarded almost as a major operation in adults past middle life Where infection of the tonsils is suspected but not proven, little is likely to be lost ultimately by treating them conservatively for a time by means of Mandhl's paint or organic silver preparations, in conjunction with pastilles of colloidal iodine several times daily

Postnasal catarrh is a frequent finding in cases of rheumatism and may in some cases constitute a low-grade primary infection sufficient to maintain activity of the disease It is often, however a sign of infected nasal sinuses, especially the antra A sulphanilamide spray or paint will be of value in streptococcal cases in others dilute protargol In many cases it is wise to give routine instructions for the hygiene of this region The following is a sheet used in the Department of Chronic Rheumatic Diseases of the West London Hospital

1 Gargle with Lotio alkalinus or normal saline morning and night
2 Sniff an alkaline solution up both nostrils morning and night
3 Brush the teeth once a day at least
4 Breathe through the nose

It must be rare for the *sinuses* not to share in any generalised infection of the nasopharynx to some degree It is not necessary for there to be a profuse nasal discharge or polypoid formation for the sinuses to be the origin of toxic condition in the body It is always suggestive of sinus trouble if a redness and swelling is seen of the lateral pharyngeal columns of lymphoid tissue which lie behind the posterior pillars of the fauces Also if the posterior wall of the pharynx is red and glazed in appearance These conditions sometimes give rise to a swelling of the small glands in the posterior triangle of the neck This adenitis may in itself be the cause of "stiff neck," and this symptom should therefore give rise to suspicion of sinus more particularly antrum, trouble The treatment of such sinuses will generally be surgical if the infection is definitely proved In doubtful cases, however, an aspiration followed by lavage with norm saline and culture of this fluid subsequently will often help to mak the diagnosis

Palliative treatment will include nasal insufflations, protein silver applications, which should probably be applied by the displacement method however since in many cases they do not otherwise enter the sinuses Short-wave diathermy is now much used, but is principally of value in the more acute cases, whilst vaccine therapy is of value in certain cases Palliative treatment should be tried in all cases other than acute ones, prior to embarking on surgical procedures More recently sulphanilamide and its chemical colleagues and penicillin have also been added usefully to our armamentarium

Chronic non-specific infection of the *prostate gland* appears as the result of army experience to be more common than was previously suspected and may well be suspected, when present, of acting as a

focus of infection which may influence the course of fibrositis Infection may be suspected if as the result of rectal examination the prostate be found to be asymmetrical, or enlarged and slightly tender. Several prostatic massages should be given and a bead cultured from the third or fourth The discovery of any specific organism will indicate direct therapy, whilst the general treatment will include a continuation of prostatic massage once or twice weekly, possibly with the addition of rectal diathermy.

The *cervix* is stated by some authors to harbour infection which may lead to fibrositis There is, however, no very definite scientific evidence that this can occur.

These matters are further discussed in the chapter on Focal Sepsis.

Vaccines

Vaccines have not been found to be of much value in the treatment of fibrositis, although lip-service is still paid to their value in cases in which a focus of infection can be found. Certain writers advocate the use of an autogenous vaccine in those cases in which a pure culture can be grown from such a focus, but others, such as Buckley, state that a mixed stock vaccine is likely to be of greater value, since such patients can be presumed to be sensitised and the indication is for small doses of a non-specific desensitising agent. The modern tendency in vaccine treatment has been a progressive diminution of the size of the dose administered, and few practitioners of this method of treatment now give a larger initial dose than 0·1 c c. of a vaccine containing 5,000,000 organisms per c.c. If any *generalised reaction* should occur, such as malaise, pyrexia, or an increase in the severity of the condition, subsequent dosage should be reduced, since it is now generally accepted that such reaction is undesirable and not beneficial as was previously hoped. Four or five days should elapse before another injection is given, and this should be reduced to at least half of that which provoked the reaction The significance of *local reaction* at the site of injection is still debated. In all probability, however, it has no specific significance but is merely tissue reaction to local irritation induced by the injection. In the absence of general reaction, the dose of succeeding vaccine injections may be cautiously raised if so desired If, as is now generally believed, however, the desideratum is to desensitise, rather [illegible] should generally be unnecessary t[illegible] "working the dose up" is often [illegible] practitioner

A vaccine made from the bacterial flora of the intestinal canal is sometimes advocated, although it is difficult to see on what scientific basis this practice can rest

A gonococcal vaccine given in large doses for its non-specific "protein-shock" [illegible] and good results reported, whilst [illegible] ieficial, although empirical, effect [illegible] B E.T. tuberculin to a mixed stock vaccine, tuberculin being the only non-specific

out, however, that that the greatest d that an equally good effect could in most cases be produced by other methods

Protein Shock

The intravenous injection of T A B vaccine, milk, or peptone has been advocated in fibrositis for the relief of pain which often follows the

whether its use is justified in fibrositis, more particularly as the beneficial effect is apt to be only temporary. The intramuscular injection of sulphur, or such commercial products as "Aolan," will be harmless and may be helpful, provided that the patient can be confined to bed until the pyrexia has passed The probable mode of action of remedies of this type is in temporarily altering the osmotic value of the extracellular fluids, and so affecting the distribution of the intracellular water

Physical Treatment

External treatment applied by physical methods is the most useful and positive procedure at present available in fibrositis The methods to be employed will, however, depend upon the condition of the patient, who may be (1) in the acute phase or (2) in a chronic or convalescent stage

(1) In the acute phase rest for the affected part is generally

be subject
however,
or, if it is
For the
general m
resistance
method used for this purpose is ultra-violet light.

Once the patient can tolerate local physical treatment heat should be applied, since this will relieve congestion by increasing the local circulation and relax any muscular spasm which may be present The best method of applying heat at this stage will be, in increasing order of complexity hot-water bottles, electric pads, radiant heat and infra-red rays, the last being rather more penetrating in its effect than the others, and so desirable if the lesion is believed to be deep-seated Diathermy has little real place in the treatment of fibrositis since the lesions are seldom deep enough to lie at the level of its maximum effect

As soon as active movement by the patient is possible this must be encouraged, particularly after application of heat. The previous enforced immobility may have led to considerable stiffness and even intramuscular adhesions, so initial difficulty may be encountered if this procedure appears to lead to a recurrence of pain Movement must, however, be persisted with and the patient encouraged to believe that it will result in a quicker return to the normal.

The next step will be to introduce *massage*. If it is employed too early the patient will tend to rely upon it to effect his cure and will be less likely to undertake early active movement Once this has been achieved, however, massage should be employed in an attempt to "break up" the trigger points or nodules from which the pain is referred. This may often be achieved more simply by introducing the point of a hypodermic needle into them and injecting 5–20 c.c of 1 per cent novocaine in saline under pressure Even if this procedure is successful, however, the massage will complete the process and prevent recurrence

The patient must be encouraged to be up and about as soon as possible, since the muscular movement incidental to this will exert a massaging effect on the affected tissues from inside Due precaution against chill or strain at this stage must, however, of course be taken, and it is best if he remain indoors.

(2) In the chronic phase also active movement is the keynote of successful treatment, since if full range can be maintained, fibrositis will find it difficult to maintain its footing.

In this condition also heat is useful as a preparation for movement, and for the same reasons It must not, however, be thought to be in itself curative in the chronic phase Counter-irritation such as is afforded by procedures like histamine ionisation or the production of erythema by the Kromayer lamp are also often useful in much the same way

Movement must be active and progressively increased against resistance In many cases of chronic fibrositis actual muscle-wasting will be found to have taken place if measurements are taken, and unless this is restored to normal no cure is likely. The exercises must be suited to the part affected, and should at first be of short duration, but frequent. Later, the duration should be increased and the frequency decreased

Massage is also useful in this stage and should be directed to the trigger points and nodules. It should be somewhat painful if it is to achieve its object of dispersing these Massage "to redevelop muscles" is useless, since nothing but movement will achieve this

Local injections are also useful in this stage but the result desired becomes increasingly difficult to achieve as the condition becomes more chronic.

If adhesions have occurred, as the result of poor treatment during the earlier stages, manipulation may be indicated. This is often strikingly successful in relieving chronic headache which results from occipital fibrositis

Spa treatment is useful in many cases It should be considered

rationally, however, as implying the application of physical methods of treatment under the best possible circumstances for the patient There are certain hydrotherapeutic methods also available at many spas which are not obtainable in most towns, and if these are indicated this may determine the correct choice of a spa In many cases, however, it seems that it is the selection of a good spa doctor, rather than the specific attributes of a particular locality, which is of major importance

X-ray therapy has seemed to have but little place in the treatment of fibrositis, in view of the uncertainty of its ætiology and the wide extent of its activities The number of exposures needed to produce an analgesic effect will also introduce an element of danger in such cases.

A method of physical treatment which is sometimes successful in cases of fibrositis which have proved intractable to other methods is the injection of oxygen subcutaneously This has been mostly employed in cases of sciatica The rationale for this method of treatment is unknown, and a theoretical danger is gas embolus, whilst the surgical emphysema which often spreads gradually upwards sometimes frightens the patient

Prophylactic

To cure a patient of fibrositis should not be our ultimate goal—we must also aim at preventing further attacks The various considerations which will enter into this will include change of employment if it is thought that this was instrumental in causing or localising the

ing depends upon its power of retaining the warm layer of air next to the skin, but allowing the passage of the moisture exhaled Only wool or the cellular
these materials mus
as well as heat cr
circumstances will inaugurate chill

Finally, regular and not too strenuous exercise is advisable for the fibrositic subject throughout life

W S C. COPEMAN

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CHAPTER XXIV

THE SPECIFIC ARTHRITIDES

1. Gonococcal Arthritis
2. Joint Syphilis
3. Tuberculous Arthritis
4. Pneumococcal Arthritis
5. Purulent Arthritis, and the Multiple Acute Suppurative Arthritis of Infancy
6. Meningococcal Arthritis
7. Neuropathic Arthropathies.
8. Dysenteric Arthritis.
9. Arthritis as a Complication of Other Diseases

GONOCOCCAL ARTHRITIS

Until recent years, gonococcal arthritis was one of the tragedies of medicine Permanent crippling with extensive destruction of bone was a common sequel To-day, the introduction of penicillin, the sulphonamides, and fever therapy have entirely altered the outlook. For this reason the early diagnosis of the condition has become a matter of great urgency Unfortunately, it can also be a matter of great difficulty It is common experience that the gonococcus may be suspected many times, without confirmation but on the one occasion when it is not considered it proves to be the causative factor The points which make the diagnosis of gonococcal arthritis likely are set out in the following paragraphs, but the best way not to miss the diagnosis is to have it constantly in mind

The Diagnosis of Gonococcal Arthritis

The history is useful only when it is positive. A negative history may be entirely misleading It does not necessarily follow that this is deliberate deception on the patient's part

It is always said that the arthritis develops *within three weeks* of the infection, but it some cases this period may be considerably extended In one case, if the history was to be relied upon, it developed *six years after*

The *age incidence* is usually given as 20–40 but it may develop at any age It is more common in males.

The process may start *in the hands, affecting many joints*, and œdema may be a marked feature. If this is linked with a rather sudden onset, a temperature ranging from 100° F–104° F a high white count and a raised sedimentation rate, the alternative diagnosis may occasionally be rheumatic fever, or even an osteomyelitis Very careful examination is required, as it may be found that the condition is more of a teno-synovitis than an arthritis, and that some of the œdematous swelling is not due to true œdema but to synovial

effusion into tendon sheaths This is very suggestive of gonococcal infection After a week or two, the trouble usually seems to settle in one medium sized joint, generally a knee, ankle, or wrist (Fig 165) As this occurs, the intensity of the infection seems to die down somewhat, and the clinical picture becomes more like the usual textbook description



Fig 165

A case of *gonococcal arthritis* after treatment with penicillin and the sulphonamides The mid-phalangeal joint of the middle finger shows residual deformity, but the patient has no symptoms

An alternative course is for *several medium-sized joints* to be involved, and then gradually the disease is concentrated *in one*. The arthritis can be *very painful* and is associated later with marked muscle-wasting. A gonococcal tenosynovitis is a common accompaniment and sometimes a gonococcal *periostitis occurs*. *Synovial effusions* are very common in joints and tendon sheaths.

The X-ray appearances are not typical but in expert hands may suggest the diagnosis *Decalcification* and osteoporosis are associated with localised destruction of bone This shows as an area of intensified rarefaction associated with erosion The patella is often affected New bone deposits are sometimes seen along tendinous attachments

Laboratory findings can be very helpful *The gonococcal complement-fixation test* varies in usefulness, and depends a great deal on the laboratory where it is performed There are two or three important points It is positive in a small proportion of cases of rheumatoid arthritis. It is negative for four to eight weeks after infection, and in a small proportion of cases is always negative In some cases it remains positive for years On the whole, a positive result is a little more reliable than a negative one If it is negative in the blood it will seldom be positive in the synovial fluid

In suspected cases a prostatic bead should be tested directly and by culture The *synovial fluid* should also be examined bacteriologically. *This may be positive* when other *confirmation is lacking.*

Synovial fluid counts are sometimes useful. They are nearly always high with a good proportion of polymorphonuclear neutrophils The lowest count is in the neighbourhood of 9,000 cells per c mm with 92 per cent polymorphs. The count is sometimes very much higher, going up to such figures as 130,000. Gonococci can be cultured from the synovial fluid.

If all these aids are used, most cases will be diagnosed early, but there will still be a few where the diagnosis is likely but cannot be

confirmed In these cases a therapeutic test with ... sulphonamides may become necessary.

Associated Features of Gonococcal Arthritis

Conjunctivitis has been described. It ... leaves no permanent damage. The ... occur in 15 per cent of cases (Comroe, ...) ... that conjunctivitis is a feature of ... urethritis and arthritis) and is ...

Keratosis blennorrhagica is a syndrome ... polyarthritis and cutaneous ... order Is extremely uncommon.



the patient and his joints. General treatment ensures this by giving the affected parts rest during the interim period The normal methods of ensuring rest are used. padding, bandages and bivalved plaster casts Adhesions form very easily in these joints, so it is wise to put them gently through a range of passive movement daily, replacing the cast afterwards *Synovial effusions* should be tapped. *Ankylosis is not uncommon in gonococcal arthritis*

Penicillin and the sulphonamides control the infection in the great majority of cases. *Sulphathiazole* is the sulphonamide of choice An effective dose is 6 gm the first day (1 gm. every 4 hours) and 3 gm on the following days (0 5 gm. every 4 hours). If blood levels are taken (and this is unusual to-day), the aim should be to keep up a level of about 6–8 mgrm per 100 ml It is now fairly clear that the sulphonamides are more effective if they are used with penicillin It is usual to give penicillin intramuscularly every three hours, the dose is generally 15,000 units. Some physicians now give only two doses of penicillin a day, 100,000 units at each injection. This does not maintain the blood levels so satisfactorily Venereologists feel that penicillin sometimes tends to reduce the discharge only, and although it undoubtedly is curative in most cases, in some it appears that the infection is *still* dormant. In view of this the course now given lasts a week, and this is a wise precaution The same precautions and contra-indications apply in the use of these preparations as in any other condition. Although the vast majority of cases of gonococcal arthritis will be cured with this régime, there may be an occasional case which is left with some disability. Some authors report cases of sulphonamide-resistant gonococci In these cases fever therapy is still sometimes used.

Fever therapy was the treatment of choice before the introduction of penicillin and the sulphonamides. Originally intravenous T.A B injections of increasing magnitude were used for producing fever. Now the apparatus usually used is the Kettering Hypertherm The degree of hyperpyrexia aimed at varies Some authors recommend ascertaining the thermal death rate of the gonococcus before starting fever therapy *No doubt some of the failures in the past have been* due to an ineffectual degree of fever Probably a minimum effective level is 105°. This should be given for four or five hours, and will have to be repeated four or five times Comroe suggests giving ten hours of fever (106°–107°) at one session, and says it may be possible in this way to cut the sessions down to *one or two* *There is no doubt* that fever therapy is effective in a proportion of cases, probably about *50 per cent* *It is said* that this result is due to the direct thermal action on the gonococcus.

Conditions of fever therapy—The treatment can only be given in hospital with a trained technician in constant attendance Some patients become restless, delirious and even show epileptiform convulsions No doubt it is a very severe strain to throw on any individual, and if cardiovascular complications are present it is contra-indicated As anything less than the maximum permissible degree of fever is ineffective, it stands to reason that the greatest

discretion has to be exercised in selecting patients for the treatment Although most patients stand the treatment fairly well, deaths have been recorded Even after the patient has apparently been cured he should be followed up and watched for some months as recrudescences occasionally occur

JOINT SYPHILIS

Syphilitic arthritis of all types is uncommon Arthralgias however occur in 5–10 per cent of cases of early syphilis Kuhns and Feldman (1940) found a positive Wassermann or Kahn in only one per cent of over 1,000 cases of chronic arthritis In a personal series of 507 cases, the Wassermann or Kahn reaction was only carried out in 208 cases and it was positive in 28 (13 4 per cent), but it must be remembered that these cases were selected because it was thought likely that the test would be positive A positive Wassermann does not, of course prove
although it suggests that it may
arthritis is difficult to establis
described, which are generally recognised to be syphilitic

Congenital Syphilis

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that the child refuses to move the limb, because of this the condition is often referred to as pseudo-paralysis (see Miscellaneous Lesions) There is tenderness and swelling If the epiphysis is actually separated, there will be deformity of joint outline

The *radiological picture* is characteristic with an irregular epiphyseal line, and areas of destruction running back into the shaft of the bone Periostitis will be seen on the X-ray The diagnosis is not difficult, the usual stigmata of congenital syphilis will be present and the difficulty will be to separate the condition from scurvy Scurvy does not usually occur till the second half of the first year of life

Syphilitic dactylitis may appear on the fingers or toes, and generally affects the proximal phalanx

Clutton's joints are usually described as a *painless bilateral synovial* effusion of the knees They occur between the ages of six to fifteen, and were first described by Clutton in the *Lancet* in 1886 Joints clinically inseparable from Clutton s joints are sometimes seen in much later life

A case of Clutton's joints in later life F W Age 23 Soldier

Five months before admission left knee became stiff and swollen, ten days later right knee swelled, but neither was painful A few days later mistiness of vision developed in the left eye, which was inflamed and watered copiously Five weeks later a similar condition developed in the right eye, with marked photophobia

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Congenital Syphilis

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referred to as pseudo-paralysis (see Miscellaneous Lesions) the limb, because of this the condition is so painful There is tenderness and swelling If the epiphysis is actually separated, there will be deformity of joint outline

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This soldier had been serving in West Africa. In the past he had suffered from malaria and scarlet fever

On examination the following abnormalities were found T 99 0, bridge of nose depressed at the base. *Swelling of both knees with thickening of synovial membrane and patellar tap.* ¾ of an inch *wasting right thigh.* Some limitation of flexion and flexion-deformity of 5°. *Eyes show interstitial keratitis with irregular Argyll Robertson pupils (Miss Dollar).*

X-ray knees shows slight irregular decalcification

Blood examination shows 90 per cent. Hb. and 11,950 W.B C *per c.mm.* with 68 per cent. polymorphs

E S R (Westergren) 29 mm at the hour

W R and Kahn +ve C F T negative.

Synovial fluid pH 7 2, W B C 12,150 per c mm., polys. 64 per cent. Granulocyte degeneration

This patient subsequently did well under treatment so far as his joints were concerned, but was only followed up for three months

Clutton's joints in childhood are also often associated with interstitial keratitis This is a helpful finding, but is sometimes absent, and makes the diagnosis difficult. Still's Disease is sometimes atypical and starts in the knees without pain. The most helpful point is that an early synovial effusion into the knees is uncommon in Still's Disease The sedimentation rate may be raised in Clutton's joints and so is of little assistance The X-ray appearances are near normal, whilst decalcification may appear fairly early in Still's Disease. Typically, of course, the two conditions are quite unlike, and the ... Other ... positive ... recover completely with suitable treatment

Secondary syphilis is sometimes associated with an arthritis, usually affecting the knees This is the type which is clinically like

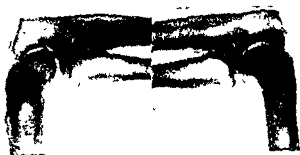


Fig 167

A case of syphilitic periostitis

Clutton's ... both knees are often affe... e limitation of movement ... ts are involved, but this is ..., the history of infection, ... rology, and the

X-ray findings, which are usually minimal (like Clutton's joints). Occasionally in case of difficulty the synovial count is helpful It rarely rises above 2,000 per c cm The condition appears to clear up with antisyphilitic treatment, and physical treatment to prevent adhesions

Tertiary Syphilis

Some authorities say that joint lesions are more common in tertiary than secondary syphilis This is probably true if the incidence of Charcot's joints is considered A synovial form of gummatous arthritis is described. This is said to resemble tuberculous arthritis by some authors, but is usually associated with little pain The pathological entity is established, for gummatous infiltration of the tissues round the joint extends into the cavity and involves the synovial membrane Occasionally the joint cavity is invaded by a gumma arising in a neighbouring bone, and erosion of cartilage arises therefrom It is said that suppuration may ensue These joints show little evidence of inflammation, but the condition may be suspected if a monarticular arthritis occurs in an adult with a positive Wassermann or Kahn reaction More work is required on this type of arthritis

Charcot's Joints occur in 4 per cent of cases of tabes dorsalis They are said in the text-books to be painless, but quite a proportion are painful at times Careful examination will reveal some sign of tabes in the great majority of cases, but in a few the joint condition itself is the first sign of tabes The reaction of the pupils and the presence of the knee jerks should form part of the examination in any case of locomotor disorder

In early cases, and especially if pain is a marked feature, the diagnosis may be difficult and the history is seldom helpful The blood and spinal fluid Wassermann may be negative in some cases The *synovial fluid* count may be helpful, if sufficient fluid can be obtained Total cell count ranges between 1,000 and 5,000 per c mm For some reason polymorphonuclear cells usually predominate

The advanced cases showing great hypermobility, laxity of all ligaments, and the "bag of bones" sensation are, of course, easy to diagnose A point not often mentioned is that the condition may be bilateral, and sometimes both hips are involved Although the knee is the usual joint, almost any joint may be affected The *X-ray* is helpful in most cases There is increased density of the bones, narrowing of the joint space and many loose bodies, with general

to be due entirely to loss of sensation Some think trauma to the insensitive joint is a feature It has been shown that section of the afferent nerves to the hip joint may lead to a very similar condition, and this effect has been thought to be a factor in osteoarthritis Possibly this factor coupled with loss of deep sensation and repeated

microtrauma to an insensitive joint may suffice to account for the condition,

Unfort

joints have

and in the later stage some attempt may be made at fusion, especially if stabilisation of the joint cannot be effected by orthopædic apparatus

Syphilitic Spondylitis

This condition is a great rarity despite statements to the contrary. It is diagnosed on certain symptoms which include pain in the

of syphilis must be present, and improvement under antisyphilitic treatment Some cases have been published with the diagnosis of syphilitic spondylitis, based on grounds which are altogether too slender. No personal experience is available. The *Charcot spine* shows great destruction of bone with extensive new bone formation

Tuberculous Arthritis

The regular pasteurisation of milk has lessened the incidence of tuberculous arthritis and pulmonary tuberculosis

In days when the disease was more common, a great point used to be made of its site of articular origin. Differences were pointed out



FIG 168

Specific Arthritides

A case of tuberculosis of the shoulder joint with the normal shoulder for comparison

between those cases originating in bone and those *beginning in* synovial membrane It seems fairly clear now that in those cases which show tubercles in the synovial membrane tuberculous granulation tissue generally occurs in the subchondral bone. Although it is possible that changes may occur primarily either in bone or synovia, both are generally affected early in the clinical course of the disease Tubercles are never seen in cartilage, and probably most often occur

at the site of most prolific vascular supply, the junction of synovial membrane and cartilage Tuberculous arthritis must be regarded as the local manifestation of a systemic infection with the tubercle bacillus

Incidence depends on the type of institution which publishes the figures Rosencrantz *et al* (1941) found between 3–4 per cent of bone and joint lesions in a general tuberculosis hospital In an orthopædic hospital 22 per cent of patients suffered from tuberculous arthritis On a general medical service 2 4 per cent of cases were found (Steinbrocker, 1941) It is now generally agreed that bovine strains are becoming less common, because of increasing control over dairy herds and more universal pasteurization

Distribution of tuberculous lesions. spine, 33 per cent , hip, 15 per cent , fingers, toes and long bones, 11 per cent., knee, 8 per cent , elbow, 4 per cent , shoulder, 3 per cent , ankle, 3 per cent , wrist, 2 per cent (Rosencrantz *et al* (1941), quoted by Comroe (1944))

Diagnosis

The stage of invasion may be acute especially if it follows injury, but as a rule it is gradual The usual symptoms of chronic constitutional illness are present malaise, pyrexia, tachycardia and loss of weight with night sweats The local manifestations in the affected joint are pain, stiffness and doughy swelling without fluid "Night starts" are common in children and muscular atrophy may occur The constitutional symptoms may be absent It is well to remember that 85 per cent of cases of tuberculous arthritis are *monarticular* Polyarticular involvement does not exclude tuberculosis but makes it unlikely *Family* history or *personal* history may be positive for any form of tuberculosis, in a personal series of cases both were disappointing

A *tuberculous joint* may occur at any age, but is most common in children up to fourteen years of age In a consulting practice dealing largely with adults about 2–3 cases come every year with the diagnosis of rheumatoid arthritis which turn out to be tuberculous

Pointers in the Diagnosis

1 A synovial effusion is against tuberculosis

2 The *X ray appearances* may be entirely normal. Osteoporosis is the first X-ray sign but may itself be long delayed Occasionally areas of dense sclerosis appear in the subchondral bone alternating with areas of decalcification, giving a kind of mottled appearance This is probably due to tuberculous granulation tissue filling up the marrow spaces At a later stage marginal erosion of the joint may occur (see chapter on Radiology), loss of joint space, and finally irregularity of the joint outline X-ray appearances are most unhelpful at the time they are really required, but a really skilled

microtrauma to an insensitive joint may suffice to account for the condition, both in tabes and syringomyelia.

Unfortunately, anti-syphilitic treatment has no effect, and these joints have to be treated on first principles with rest, immobilisation, and in the later stage some attempt may be made at fusion, especially *if stabilisation of the joint cannot be effected by orthopædic apparatus.*

Syphilitic Spondylitis

This condition is a great rarity despite statements to the contrary. *It is* diagnosed on certain symptoms which include pain in the *back (generally* in the dorsal and cervical regions), *stiffness, and other* evidence of syphilis. Root pain may be particularly *severe.*

Presumably a syphilitic osteitis of the vertebræ is the pathological *lesion,* and X-rays may sometimes confirm this. Serological evidence *of* syphilis must be present, and improvement under antisyphilitic *treatment. Some cases have been* published with the diagnosis of syphilitic spondylitis, based on grounds which are altogether too slender. No personal experience is available The *Charcot spine* shows great destruction of bone with extensive new bone formation

Tuberculous Arthritis

The regular pasteurisation of milk has lessened the incidence of tuberculous arthritis and pulmonary tuberculosis

In days when the disease was more common, a great point used to be made of its site of articular origin. Differences were pointed out



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3. A *Mantoux or Von Pirquet Test* may help if it is negative A positive test means nothing in a patient over 4–6 years old

4 A *diagnostic arthrotomy* with examination and culture of the aspirated fluid may be helpful. Guinea-pig tests should be carried out, but the six weeks' delay in getting an answer is rather baffling.

5 A *diagnostic biopsy* of synovial membrane has been very popular in the past, and no doubt is very helpful in cases where a positive diagnosis cannot be made, but the sinuses which may form after such a measure should make it a last resort It should never be undertaken in children.

6 Sometimes "night starts" help. As a rule these come late because they [illegible]
sometimes th[illegible]

7 Never f[illegible]
in the shape of glands or lung signs. It seems reasonable to say that a chest X-ray should be taken in *every case* of arthritis in which the diagnosis is in doubt

Treatment of tuberculous arthritis is an orthopædic problem. So much depends on whether the lesion is extra-articular or intra-articular in the first place, that an *orthopædist should be consulted immediately* the diagnosis becomes likely

Pointers with regard to Tuberculosis of the Hip Joint

1. This type is almost confined to children

2 The pain is often felt in the knee through the obturator nerve.

3 The hip joint is, however, often tender on pressure, and the muscles round it are in spasm

4. An actual swelling over the hip may often be seen

5 Orthopædic surgeons now try to diagnose the condition before the stage of flexion, abduction and external rotation of the thigh This is difficult, as children often come for consultation with this sign already present

6. Burns and Ellis (1939) describe three early X-ray changes (*a*) rarefaction of the bones forming and round the joint, (*b*) an indefinite bony outline to the joint; (*c*) loss of joint space due to erosion of cartilage

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Treatment is mostly carried out by orthopædic or specialist surgeons and in special institutions In the early stages much may be done by rest, heliotherapy and cod-liver oil

TUBERCULOSIS OF THE SPINE (POTT'S DISEASE)

Is the commonest form of tuberculous bone and joint disease, and is most often found in the lower dorsal spine (over 50 per cent)

The commonest site of origin is the body of a vertebra, and one or two vertebræ may be involved, but occasionally the surfaces of a vertebra may be attacked, and if the posterior surface is involved the signs and symptoms may simulate a spinal tumour. The anterior surface is, however, more commonly attacked An intervertebral

disc may apparently be involved early in the course of the disease, but Burns and Ellis (1939) say that the "fading away" of the disc seen in X-rays is due to interference with its nutrition, because the two metaphyses on each side are diseased

The syndrome is fairly easy to diagnose The child (the disease is far more common in children) develops an awkward gait, the spine is stiff and painful to move, there is weakness in the back, and the pain is most marked at night Hyperextension of the hips (with the patient prone) reveals extensive muscle spasm in the spine. *X-ray appearances* are difficult of interpretation *Rarefaction* of the bodies of one or more vertebræ appears first, *blurring* of the upper or lower



Fig 169

X-ray showing decalcification of one hip This was mistaken at one time for tuberculous arthritis, but has no real resemblance

edges of the bodies appears somewhat later, and in some cases the "fading away" of the intervertebral disc is a feature.

Osteochondritis of the spine usually affects one vertebra only, and this becomes wedge-shaped, but the intervertebral discs are intact Both anteroposterior and lateral views of the spine are necessary and the very best radiological technique

The *two complications* which commonly occur are *paraplegia* and the *formation of a cold abscess* The *abscess* may remain localised to the anterior portion of the spine behind the common ligament, leading to the "aneurysm" phenomenon of Ghormley and Bradley (1928). Erosion of the bodies of the vertebræ takes place as in the case of aortic aneurysm, leaving the discs intact Alternatively and more commonly the abscess may become a psoas abscess or a retropharyngeal abscess *Erosion* of the bodies of the vertebræ leads to the typical "*angulation*" of the spine, and occasionally this may be the first sign.

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about 20 per cent of cases Butler and Seddon (1935) have studied the ætiology and prognosis of paraplegia in Pott's Disease and have introduced a classification based on the time relationship of the complication to the main disease From this data they have provided a very useful scheme of treatment. Reference should be made to the original work, which is also fully described by Burns and Ellis (1939)



FIG 170

Secondary deposits in the spine in a case of bronchial carcinoma

Pulmonary tuberculosis is said by some authors to occur *in* 40 per cent of cases, this figure is probably too high When it occurs it

ints represents a diagnostic on the X-rays Those cases which show positive X-ray signs in the sacro-iliac joints must be carefully separated from cases of *ankylosing spondylitis* with a "sacral focus" (see chapter on Ankylosing Spondylitis)

In a large series of cases of Pott's Disease healing occurred in 35 per cent. of cases.

Treatment is general and orthopædic.

Tuberculosis Dactylitis is mostly seen in children, just as tuberculosis of the knee joint and sacro-iliac joints is mostly seen in adults.

PNEUMOCOCCAL ARTHRITIS

The secondary type is a rare complication of lobar pneumonia but most specialist physicians see one or two cases a year

Clinically, arthritis develops in one of two ways *On the second or third day* of a case of lobar pneumonia pain, swelling, heat and stiffness develop in one or more joints, usually the knee, elbow, wrist, or ankle Limitation of movement and periarticular swelling are marked features and synovial effusions are sometimes seen At this stage the typical leucocytosis appears, ranging from 12,000–20,000 cells per c mm The usual physical signs and constitutional evidence of pulmonary consolidation are present, the pulse respiration ratio has fallen to 3 to 1, or 2½ to 1, and the patient presents the cyanosed flushed appearance typical of the disease At this stage the diagnosis is obvious and the effect of sulphonamide therapy is usually just beginning to be felt Rheumatic nodules are, of course, absent



FIG 171

Residual deformity in a case of pneumococcal arthritis About 10 limitation of flexion remained, but there were no symptoms

Alternatively, the arthritis may antedate the pulmonary signs by 24–48 hours, but not as a rule longer In this case the arthritis may sometimes be polyarticular so that a streptococcal arthritis may be suspected Within a day or two, however, the position becomes quite plain as the fully developed picture of pneumonia appears

Treatment is important The joints should be immobilised, but put through a range of movement each day The routine treatment of pneumonia is with one or other of the sulphonamides, but this will not by itself prevent the appearance of arthritis Directly the complication appears the joints affected should be injected with penicillin About 500 units is a suitable amount for the knee joint and may be repeated. Penicillin may also be given systemically in combination with whatever sulphonamide is being used, and it certainly seems as if this combination is more effective than either agent by itself

With this régime the great majority of cases recover full function of their joints

Primary Pneumococcal Arthritis is very rare, but it does occur *The diagnosis is difficult but may be suspected* in a patient with severe constitutional symptoms and the involvement of a single joint.

The routine X-ray and laboratory examinations are helpful, but the diagnosis must be clinched by culture of the pneumococcus from the joint or blood. The difficulty here is the delay that must occur before this can be done. The differential diagnosis usually lies between a gonococcal, tuberculous, purulent, or pneumococcal arthritis, *depending to a great extent on the severity of the infection* and the type of patient. In view of the great damage that may accrue to a joint if treatment is long delayed, it is usual to treat these border-line cases with penicillin and the sulphonamides. In consequence some cases of primary pneumococcal arthritis may be missed, as the joint becomes sterile in a short time, and cultural confirmation is lacking

PURULENT ARTHRITIS

The common organisms are the staphylococcus and the strepto-coccus, unusual ones are the pneumococcus (already described). B.

the

an effusion and local œdema. A leucocytosis of 15,000–30,000 cells per c.mm. is usual. The joints commonly affected are the hip and the knee, and children are more often affected than adults

Apart from trauma, these joint infections are usually secondary to a mastoid infection, furunculosis, or infected tonsils, but they may be primary or associated with a generalised septicæmia with no known focus

The diagnosis and ætiology are usually confirmed by joint puncture, and this should be done (with aseptic precautions) at an early stage

Treatment may have to be surgical, but physicians should be aware of certain facts with regard to chemotherapy.

Sulphonamides —After absorption the sulphonamides pass rapidly into the articular fluids *The exact concentration obtained in the* fluid is not accurately known and probably varies with the preparation administered It is likely that sulphadiazine is the compound of choice, as not only does it belong to the more active class, but its penetration into the cerebrospinal fluid (probably some measure of its penetration into joints) is relatively high

Streptomycin.—Streptomycin promises to be a very useful adjuvant to penicillin as it is markedly active against gram-negative bacteria as well as gram-positive bacteria

It would appear from the results of Zintel *et al* (1945) that streptomycin probably appears in joint fluids after intramuscular administration These workers found that though the diffusion into the cerebrospinal fluid was not rapid, the substance appears in the pleural and peritoneal fluids of cases with effusions in bacteriostatic concentration following intramuscular administration.

Heilman *et al* (1945) have administered up to 100,000 units of streptomycin (in 10 c c of saline) intrathecally without untoward

result, so that the substance can almost certainly be used by intra-articular injection

Balboni *et al* have shown that penicillin injected intramuscularly is found in patients with joint effusion in equal quantities in the effusion and the blood The penicillin joint levels falls a good deal less slowly than does the blood level McAdam *et al.* (1945) showed that a dose of 100 000 units a day intramuscularly was sufficient to



Fig 172

Purulent arthritis This joint had been the site of a pyoarthrosis 20 years before The cartilage has been partly destroyed—the spines are missing and the contour of the bone is unusual Functionally this was a very good joint



Fig 173

An X ray showing the end result of a purulent arthritis This joint was the subject of an acute streptococcal arthritis 30 years before this picture was taken A fair amount of movement still remained but the joint was painful after an accident

produce and maintain an adequate bacteriostatic concentration in the joint fluid of four out of five cases of septic arthritis They also observed that in joints of persons suffering from septic arthritis a single injection of 25,000 units maintained a bacteriostatic con centration for two days

A consideration of this work makes it evident that the effect of chemotherapy in acute suppurative arthritis may be of the greatest possible importance

MENINGOCOCCAL ARTHRITIS

It is becoming clear that the meningococcus may produce articular and other locomotor lesions *under a variety of circumstances*, and these manifestations will be considered under two heads, those occurring

during the course of meningococcal meningitis and those found in chronic meningococcal septicæmia.

The Articular Lesions of Cerebrospinal Fever

As in so many other acute infective fevers, the disease may

remain in doubt. Such a period lasts a variable time, and the appearance of meningeal signs and a rash usually settles the question. This sequence of events does not always occur and in epidemics *abortive forms are well recognised*, as also is the chronic septicæmic form

If the *fully developed meningeal syndrome* develops, accompanied by the characteristic headache, vomiting, neck signs and rash, an arthritis may appear *as a complication*. Since the introduction of the *sulphonamides* the arthritis is not so severe as it used to be, and generally clears up completely Nevertheless an effusion which may be purulent sometimes occurs and the joint may be red and tender. This condition will not be easily confused with the joint pains which sometimes follow the use of the sulphonamides (sulphatoxic arthritis), as they are not as a rule accompanied by effusions of any magnitude, and clear up when the drug is withdrawn. In a series of 74 cases of meningococcal meningitis seen over five years, an arthritis of the type described developed in 3 cases, so that it is uncommon. In one severe case seen in the country, an intra-articular injection of penicillin into the right knee cleared the condition up in forty-eight hours, so far as the acute signs were concerned. The routine treatment of an acute arthritis must be observed

Chronic Meningococcal Septicæmia

As already mentioned, these cases may occur in the course of an *epidemic*, but they may also occur *sporadically*

Stott and Copeman (1940) described a series of cases which occurred during an epidemic of cerebrospinal fever amongst the troops in France They describe the symptoms as headache, muscle and joint pains and effusions, intermittent fever, and a skin rash, often purpuric, which *was tender* This rash is rather protean in nature and may consist of papules, macules, or even *nodules* Its tenderness is a fairly constant feature, and the spots often have hæmorrhagic centres, they usually fade on pressure. Joint effusions sometimes occur Copeman's view is that this is a common disease, but that it is frequently misdiagnosed, generally as rheumatic fever or influenza, or as erythema nodosum when the rash is confluent The blood cultures of nearly all cases are positive for the meningococcus The sulphonamides will clear up the condition in twenty-four hours if given in adequate doses

This is undoubtedly a condition which should be borne in *mind*, for apparently it has a chronic *tendency*, and no great capacity for

self-resolution Looking back, a good many puzzling cases may have been of this nature

THE NEUROPATHIC ARTHROPATHIES

[illegible] accounted for [illegible] in the [illegible] bs It [illegible] ts may [illegible] ics and syringomyelics never develop joint trouble (see p 387)

Some people think that occupation and use may determine the site of the joint lesion, for instance, a blacksmith would develop trouble in the arm joints

Syringomyelia is associated with other trophic changes such as overgrowth of a hand (cheiromegaly), and X-rays confirm that the bones may show greatly increased density and enlargement or, on the other hand, rarefaction The joint lesions generally correspond with the spinal ones, and in those unusual cases where joints of the lower limb are concerned the spinal cavities are usually, but not always, found in the lumbar region of the cord Perhaps interference with articular sensation, coupled with the unwitting trauma which may follow, *partly* accounts for this type of neuropathic joint

The *pathological changes* include erosion of cartilage with bony destruction, closely followed by intense bony proliferation and exostoses The joints are usually painless, whereas Charcot's joints are sometimes painful The diagnosis presents little difficulty, the muscular atrophy, site of the lesion and the dissociated anæsthesia make it plain In the same way Argyll Robertson pupils and absent knee jerks point the way to the Charcot joint

THE ARTHRITIS OF DYSENTERY

Arthritis has been well recognised as a complication of dysentery for many years, and although it may accompany either the amœbic or the bacillary forms it is usually associated with the latter In either case it usually follows closely on the parent disease

The proportion of cases which develop arthritis is variously estimated at from 0 3 per cent to 10 per cent , a fair estimate is about 2 per cent

The knee is the joint principally affected, but occasionally the elbow is involved On rare occasions the hip has been reported as the only joint affected

The symptoms and mode of onset are so variable that no general description can be given Sometimes the onset is acute with recrudescence of pyrexia, on other occasions the arthritis slowly develops without much in the way of symptoms except local pain and disability Effusions are variable, in the acute cases they are seen, and bacilli of the dysentery type have been cultured from them (Dudgeon, 1919) In the more chronic cases they do not occur

Most authorities agree that the joints resolve completely, but

in the recent war a good many cases have been returned from the East with considerable pain, disability and limitation of movement. Presumably many more have recovered and continued their Army career

Most observers regard the condition as allergic in origin, as evidence of direct infection in the joint is so rare, but in chronic cases little collateral evidence can be obtained of allergy, so that incomplete resolution of an infected joint seems on the whole more likely.

Treatment at this stage is most unsatisfactory, and general principles must be followed

This chapter has included so far only those conditions in which the connection of the arthritis with the main disease is sufficiently close to justify the title of "specific" arthritis The remainder of the chapter will deal with syndromes in which a close relationship is partly or entirely lacking, but in which, nevertheless, arthritis occurs in such a proportion of cases as to make it likely that more than a mere accidental association exists

ARTHRITIS AS A COMPLICATION OF OTHER DISEASES

B. COLI INFECTIONS

These infections, especially affecting the genito-urinary tract, are undoubtedly very common In the study of any series of syndromes it would be natural to meet cases with an associated coliform pyelitis Taking full account of this fact it still seems that these infections are found in an abnormal number of cases associated with arthritis The following abbreviated case report may give an indication of the circumstances in which such infections may occur:

J F Age 26 ♂ Soldier

Admitted to hospital June 24th, complaining of pain and frequency of micturition T 102°, P 96, R 20 Examination of the urine showed many [illegible] The physical examina- [illegible] a straight X-ray of the [illegible] anæmia was found, and the E S R (Westergren) at one hour was 40 m m A diagnosis of acute [illegible] At the [illegible] It was [illegible] e rose to [illegible] vial fluid [illegible] e Two [illegible] eturned [illegible] m The [illegible] t about, [illegible] m [illegible] the Army

It seems likely that the arthritis was secondary to the B coli infection, either with or without an allergic factor B coli infections are also commonly associated with frank cases of rheumatoid arthritis,

and the two diseases may either synchronise (not very commonly) or the pyelitis may occur during the course of the arthritis and

may entirely relieve ed in favour of the

UNDULANT FEVER

This fever has a romantic history It starts with the pioneer work of David Bruce and his wife in Malta in 1883, culminating in their discovery of the rôle played by goat's milk in the propagation of Malta Fever, and the establishment of the specificity of what was then called the *Micrococcus Melitensis* in 1893 It is continued by the work of Bang of Copenhagen and Helmholtz, the physiologist, who starting work in 1896 studied abortion in the cow, and in 1906 found a specific microbe and called it *Bacillus abortus* In 1909 the specific agglutinins to this organism were found in the blood serum To a large extent the romantic side came to an end with the work of that brilliant American, Alice Evans, who showed that *micrococcus melitensis* was a bacillus and culturally nearly indistinguishable from B abortus The antibodies in both cases were, for all practical purposes, interchangeable (John Eyre 1935).

The *symptoms* are headache, anorexia, general fatigue of a pronounced type and general muscular pains Arthritis is said to occur in 25 per cent of cases and, most importantly, may be the presenting symptom for a long time The characteristic "undulant" fever is not always present, and even when it is, cannot always be distinguished from remittent and intermittent pyrexia due to many other causes A papular or urticarial rash may be found

The *diagnosis* is clinched by the serological tests and blood culture In chronic cases the agglutinin reactions may be unreliable (Huddleson 1943) Skin tests (which become positive rather late in the disease) are made with Brucellergin, a protein nucleate solution which has superseded bacterial filtrates

A liver-broth culture filtrate was introduced in 1939 and called Brucellin After sterility tests it is given by injection in the treatment of the disease According to Benning (1946), 70 cases out of 78 were improved with this treatment alone, but it produces marked reactions and may not be entirely safe.

Dalrymple-Champneys (1938), who has done a tremendous amount of work on this subject, takes the view that it is only bovine infection and B abortus which need be feared *in this country* The porcine, caprine and ovine forms do not occur

A few cases have been reported in which undulant fever has been associated with weakness and low back pain (Bishop, 1939) Limitation of spinal movement is present and the X-ray shows destruction of one angle of a vertebra with a sclerotic edge to the lesion The intervertebral disc is intact The lumbar spine only is affected

in the recent war a good many cases have been returned from the East with considerable pain, disability and limitation of movement Presumably many more have recovered and continued their Army career

Most observers regard the condition as allergic in origin, as evidence of direct infection in the joint is so rare, but in chronic cases little collateral evidence can be obtained of allergy, so that incomplete resolution of an infected joint seems on the whole more likely.

Treatment at this stage is most unsatisfactory, and general principles must be followed.

This chapter has included so far only those conditions in which the connection of the arthritis with the main disease is sufficiently close to justify the title of "specific" arthritis The remainder of the chapter will deal with syndromes in which a close relationship is partly or entirely lacking, but in which, *nevertheless, arthritis occurs* in such a proportion of cases as to make it likely that more than a mere accidental association exists.

ARTHRITIS AS A COMPLICATION OF OTHER DISEASES

B. COLI INFECTIONS

These infections, especially affecting the genito-urinary tract, are undoubtedly very common In the study of any series of syndromes it would be natural to i
Taking full account of
found in an abnorma
The following abbrevia
circumstances in which such infections may occur:

J F Age 26 ♂ Soldier

Admitted to hospital June 24th, complaining of pain and frequency of micturition T 102°, P 96, R 20 Examination of the urine showed many pus cells, and after two attempts B coli was cultured The physical examination was negative, neither kidney was palpable, and a straight X-ray of the abdomen showed no calculus A mild secondary anæmia was found, and the E S R (Westergren) at one hour was 40 m m A diagnosis of acute B coli pyelitis was made and the patient was put on sulphonamides At the end of three weeks he was symptom-free, and the urine was normal It was decided to discharge him next day, but that night the temperature rose to 101° and the right knee became tender, swollen and painful Synovial fluid count was 12,000 cells per c mm but the fluid was sterile on culture Two days later the genito-urinary symptoms returned and the pyuria returned
The ... The
X-r ... ut,
... om
the knee never completely resolved, and the soldier had to be ... the Army

It seems likely that the arthritis was secondary to the *B coli* infection, either with or without an allergic factor B coli infections are also commonly associated with frank cases of rheumatoid arthritis,

any reasonable conclusion It has always seemed as if this is a condition in which an allergic explanation might be suitable, but there is no proof at all of this suggestion

PERIARTERITIS NODOSA

This unusual and perhaps rare condition is becoming more talked of to-day, though not necessarily more common Cases are as a rule diagnosed after death, but some have been diagnosed during life, though in most of them post-mortem evidence is lacking In addition it should be added that some (though only a very few) apparently recover Locomotor symptoms are common but arthritis rare

The lesion is said to be a low-grade infection of the arteries Collections of polymorphonuclear cells are found in the adventitia of the arteries which sometimes form nodules, eosinophils are also present The media degenerates and there is proliferation of the intima

The cases divide themselves into two forms, *generalised* and *localised*

The *generalised form* is associated with fever, tachycardia, anæmia, abdominal and other pain, as well as generalised muscular pains and arthritic symptoms

Two *local forms* are described one is associated closely with the arterial lesions, and is accompanied by local pain, thrombosis and aneurysm The other is shown by symptoms of nephritis, albuminuria and œdema The characteristic nodules, the size of a small pea, may sometimes be felt if the arteries are sufficiently superficial Recent reports show very mixed syndromes, and the nodosities have been found in few cases

In one case (Perlman, 1946) joint pain, rashes, fever and constitutional signs, with weakness of the legs suggesting peripheral neuritis, was associated with acute abdominal pain The urine showed pus and a trace of protein *Post-mortem* examination revealed nodes in the coronary arteries mesenteries and in many other visceral arteries *Other authors* have stressed hæmaturia and asthenia as leading symptoms and some have emphasised the muscular pains and the possibility of arthritis. The abdominal symptoms are sometimes so urgent that surgical intervention has been called for On one occasion unilateral renal bleeding led to a nephrectomy Hypertension and cholelithiasis are common accompaniments

Rich, who has done so much work on allergy and anaphylaxis, has suggested that vascular lesions identical with those of periarteritis nodosa can be found in anaphylactic conditions like serum sickness

Periarteritis nodosa is not infrequently seen in this country, hough the number of cases in any one man's experience is naturally mall There is no doubt that muscular pains are a very common ent especially pain over the left scapula This may be due to the istric ulceration which often accompanies the arterial lesions

From personal experience, a case which presents so many signs and mptoms that they cannot be correlated suggests diverse vascular

Perhaps it should be added that the sulphonamides (given with due precaution) are successful in a number of cases.

This matter has been considered at some length as cases of this type are *occasionally seen in this country*, and it is quite easy to forget undulant fever as a possible cause, especially if the patient is seen during an apyrexial period.

SCARLET FEVER, RUBELLA AND DIPHTHERIA

About 2 per cent of patients with **scarlet fever** develop some form of joint trouble. About the tenth day pain, tenderness and sometimes swelling occur, generally in a knee. This condition may resolve in the course

arthritis

may be he

the numbe

from an attack of scarlet fever. Some authors have described a polyarthritis as one of the complications of scarlet fever.

Rubella has recently been the subject of study from the point of view of its locomotor complications (Bennett *et al*, 1940).

In 1940 there was a sizable epidemic of rubella in England, and this also affected the Services in France. Bennett and Copeman saw more than 300 cases in an Army hospital which was made the clearing-station for the B E F in France. They found cases with locomotor symptoms which ranged from muscular pains (which themselves have been considered uncommon in rubella) to symptoms of arthritis reminiscent of rheumatic fever. Joint effusions were encountered in a number of patients and in one case (subsequently transferred to another hospital) follow-up inquiries elicited the information that the case was regarded as one of sub-acute rheumatism and carditis

features of the disease.

Similar cases were reported in England (Harrison, 1940) in which, in addition to the aching of the gums, bleeding occurred, and some of the signs of a motor neuritis in the hands were found

None of these manifestations are regarded as typical of rubella, and it will be of interest to see whether they recur in peace-time

Diphtheria has been reported to be accompanied by painful swollen joints from which the bacillus has been isolated. Personal experience of one case is that the elbow was affected, and that full function was never recovered

ULCERATIVE COLITIS

Arthritis as a complication is unusual. Treatment of the main disease is unsatisfactory, so that patients tend to be ward-bound for long periods. Perhaps in consequence of this, joint troubles are

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ise

to

reported are seen in coloured people The so-called anorectal syndrome is common with or without an ulcerating granuolma of the pudendum.

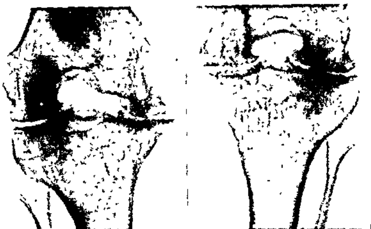


Fig 174

An X-ray of the case of hæmophilia mentioned in the text Considerable destruction of the joint has occurred (Dr Donald Hunter's case)



Fig 175

Clinical picture of a boy with recurrent hæmorrhages into both knees

GAUCHER'S DISEASE

In this condition the liver ... with the lipoid kerasin It i... familial diseases of which t... Christian syndromes are the other members

The hip joint is sometimes involved and 16 cases have been

lesions and may turn out to be periarteritis nodosa, but the superficial vascular nodosities described have never been found *Pulmonary* symptoms resembling asthma or acute bronchitis are the precursors of the syndrome in some cases

Arteritis of the temporal vessels is a condition the pathology of which is obscure Jennings (*J Path Bact.*, 1941, **53**, 263), who described the first British cases, thought it might be a variant of *periarteritis nodosa*.

It is mentioned here because the illness starts with muscular pains, generally accompanied by constitutional symptoms This stage may last for some months before the temporal artery becomes involved, and it is well to remember the syndrome when such a state of affairs is encountered

Cooke, Cloake, Govan and Colbeck (*Quart J. Med*, 1946, n s, **15**, 47) have fully described the syndrome, and those interested should read the original article

POST-ENCEPHALITIC PARKINSONISM is rarely associated with arthritis, but much more commonly with pain referred to muscles or to the spine. *It is somewhat uncertain whether the connection is as* intimate as might be thought The age incidence corresponds with that of some of the common rheumatic syndromes In one case, for instance, there was no doubt that ankylosing spondylitis had preceded the striatal syndrome

HÆMOPHILIA

The hæmophilic occasionally bleeds into his joints. For instance, J W, *age 35 in 1939, had a history of bleeding since the* age of 12 There had been hæmorrhage from the tongue, nose and gums, a cut finger bled for two weeks, there had been severe *hæmaturia* and hæmorrhage into various joints *Three other males in two* generations were known to be affected but they live abroad Coagulation time was fifteen minutes (Dr Donald Hunter's case) The *X-ray* shows the typical joint changes and some change in the bone *This* condition could hardly be called an arthritis, it is generally known as a *hæmarthrosis*

LYMPHOGRANULOMA VENEREUM

In 1939 Dawson and Boots, working in the Arthritis Clinic of the Presbyterian Hospital, reported 24 cases of arthritis in cases which gave a positive result with the Frei antigen and other evidence of lymphogranuloma venereum They themselves were a little sceptical but took every possible precaution to rule out other disease, and concluded it was a definite entity. The arthritis is of a chronic type associated with effusion and showing a tendency to relapse. It is often polyarticular Joint fluid was sterile and was never purulent Cell counts varied from 900–5,000 per c mm Neither the virus nor the Frei antigen was found in the joint fluid

Lymphogranuloma venereum is a venereal disease associated with a primary sore and said to be due to a virus Many of the cases

SCHONLEIN'S PURPURA AND HENOCH'S PURPURA

Schonlein's Purpura (purpura rheumatica) is associated with a streptococcal sore throat and constitutional symptoms such as pyrexia and tachycardia The temperature varies from 100°–103° and many joints are painful and swollen The swelling is due to the purpuric eruption, which occurs in the joints as well as in other places The eruption may also be erythematous or urticarial

The diagnosis is difficult if the joint swelling is a prominent part of the clinical picture, the sore throat seems to influence the diagnosis on the side of rheumatic fever, but if the eruption is typical the diagnosis is generally clear These cases often recover but relapses are frequent The platelet count is a help

Henoch's Purpura resembles purpura rheumatica but is usually associated with severe abdominal pain With this pain (due to the purpuric eruption in the viscera) is an associated melæna. The skin

SUB-ACUTE BACTERIAL ENDOCARDITIS is accompanied by fever and a cardiac lesion In addition pains are felt in the joints, which also swell If the blood culture is negative, the diagnosis may be in doubt Points which help are evidence of emboli into the skin, conjunctiva retina and kidney (hæmaturia), and the effect of salicylate therapy may assist in eliminating rheumatic fever

Comroe (1944) says that although sub-acute bacterial endocarditis occurs in less than 5 per cent. of patients with rheumatic fever over 50 per cent of patients with sub acute bacterial endocarditis have had rheumatic fever

A positive blood culture will generally settle the issue

A VARIETY OF CONDITIONS RARE IN EUROPE

Rat-bite Fever, Tularæmia, Valley Fever and Malaria

Rat-bite fever is occasionally seen in Europe and sometimes in children There is a story of a rat bite which does not heal properly and some weeks later, starts to ulcerate The temperature goes up to as high as 104° and is accompanied by an erythematous eruption followed by pain in the joints and swelling The disease is caused by " "

It i

sig

caused by a horse-fly there is fever with generalised joint and muscle pains

The diagnosis is made by agglutination tests and a serum has recently been used in treatment

San Joaquin valley fever is confined to this valley in California It is associated with joint pains and erythema nodosum. Coccidioidal arthritis occurs

reported. The lesions described suggest either Perthe's Disease or early tuberculosis, irregularity of the epiphyseal line with coxa-vara deformity The diagnosis is firmly established by sternal puncture when the Gaucher's cells are found.

Some cases have been treated by surgery (Cushing *et al*, 1926) Dr. Donald Hunter mentions this condition in his chapter on Medical *Diseases of Bone*

LEUKÆMIA AND POLYCYTHÆMIA

Leukæmia appears in the field of locomotor disorders under two conditions

Infantile leukæmia may be associated with joint pains and muscle pains to a very marked degree. Other signs of the blood condition will usually be found, but it is said that the salicylates deal effectively with the joint pains, so that some care is evidently required. The joint pains are probably due to a purpuric eruption in the joints, and *in acute cases purpuric retinitis occurs. X-ray of bone ends may* show an amorphous appearance.

Leukæmia may be closely associated with arthritis in older people, and this is a far more common occurrence. *Joint symptoms* are also common in *polycythæmia*.

These cases can be very puzzling, for the blood uric acid is raised in these conditions, and the diagnosis of gout is often made. Several *cases of this type have been seen and it is difficult to come to any* satisfactory conclusion The *raised sedimentation rate* and *blood uric acid* could be due to the blood disorder or the locomotor disorder. X-rays generally show decalcification only, although in one case (where the hands were affected) "punched-out" areas were seen The commonest joint to be affected is the knee, and a common symptom is pain and aching in the soles of the feet

In some cases gout and polycythæmia or leukæmia are associated in the same patient.

The following short case note gives an idea of the difficulties

M C Age 63. *Clerk.*

For 25 years this patient has suffered from bunions on both feet In 1941 he developed corneal ulcers, which subsequently cleared up, and later that year he attended hospital where he was diagnosed as polycythæmia ver[illegible] *id that the big toe of the left foot had* beer[illegible] ie heart was enlarged, with a systolic mur[illegible] The spleen was enlarged 3 fingers' [illegible] costal margin and the liver was just palpable *At this* [illegible]

pre-existing bunion The [illegible]
consistently raised [illegible]



Fig 176

Alkaptonuria The arthritis of the hip found in a case of this disease (Dr George Graham's case)



Fig 177

The appearance of the spine in alkaptonuria Note the changes in the intervertebral discs

Malaria does not have arthritis as one of its complications; joint and muscle pains are found as in other fevers.

Reiter's Arthritis

This syndrome consists of conjunctivitis, urethritis and arthritis In a series of these cases (Hollander *et al*, 1945), 25 examples of the typical syndrome showed in 11 an acute polyarticular onset with a purulent urethritis and a suppurative conjunctivitis; 14 cases showed no conjunctivitis Gonococci could not be found in films or in culture, and the syndrome was not seen in the female sex Other authors have reported skin eruptions and hæmaturia. One report (Harkness, A H (1945), *Brit J Vener. Dis.*, 21, 93) states that 16 cases have been associated with keratodermia blennorrhagica Sometimes the arthritis appears alone at the commencement of the disease, and is followed later by urethritis and conjunctivitis

Since Reiter's original report (1916), in which he stated that he thought a spirochæte was the causal organism, no constant cause for the syndrome has been found

The arthritis usually occurs in the larger joints and generally affects more than one joint Effusions are not uncommon.

The X-ray shows osteoporosis of the bone ends, which are spotty and ill-defined

Some cases have been treated with sulphonamides and some with penicillin (up to 3,000,000 units) without effect.

The conjunctivitis generally clears up on symptomatic treatment. no organisms are grown from the discharge Some cases show a residual prostatitis Pyrexia is usually present and any or all joints are involved The sedimentation rate is raised and a leucocytosis of about 12 000 cells per c.mm is usual. Synovial cell counts number from 9,000–14,000 cells per c mm with 65–74 per cent. of polymorphs

The *acute stage* lasts 4–6 weeks Most of the patients return to normal and their joints clear up, but some remain stiff and swollen without signs of inflammation. Recurrences occur in some patients but most are asymptomatic in 3 months

In some cases there is a previous history of a similar complaint In one case a biopsy was carried out but no resemblance could be found to rheumatoid arthritis

Some of these cases resemble those seen in the Middle East during the war, but no explanation as to their ætiology has been forthcoming, although a virus has been suspected Some fresh cases were published by Jackson this year (*B M.J.*, 2, 197, 1946).

The Arthritis of Alkaptonuria and Congenital Hæmatoporphyrinuria

Garrod (1923) gave the classical description of *alkaptonuria* in his book *Inborn Errors of Metabolism* In early life the condition is trifling, but as the years go on the cartilages of the ears become blackened, brown marks develop on the conjunctivæ, and the fibro-cartilages of the intervertebral discs show the same changes (ochronosis). There is some dysuria and frequency of micturition at

the nasal cartilages give a characteristic appearance The tendons are sometimes ...

... of the cartilages)

The illustrations of this condition have been kindly lent by Dr George Graham, who has followed up some of Sir Archibald Garrod's cases

This is not the place to go f...

PAGET'S DISEASE

Paget's Disease can be divided into two types, the *general* and the *local*.

In the *general type* the rarefying osteitis with enlargement of the Haversian spaces is found widely distributed on many bones, and it



Fig 179

Paget's Disease of the pelvis showing osteoarthritis of the hips

lum

mght On boiling the urme with Fehlmg's solution a deep brown colour develops, which Garrod says is characteristic. `Addition of alkali to the urme hastens the rate of oxidation and so the appearance of the dark brown colour

Gould and Thomas (1943) say that the condition can be diagnosed by making the urine alkaline with caustic soda and then placing a



Fig 178

The appearance of the spine in alkaptonuria

the latter turns instantly

(homogentisic) acid

The locomotor lesions are always said to be osseous and osteoarthritic This is not strictly true, as the changes observed are thought to be due to the changes *which follow the staining* of the cartilages, e.g. ochronosis. In the days when carbolic dressing was applied for long periods to varicose ulcers ochronosis developed, and the two conditions had to be separated Ochronosis does not develop in alkaptonuria until middle life. Any cartilage may be affected, and

joint, but in cases of *syphilitic epiphysitis*, crepitus and pain occur on moving the joints owing to the separation of the cartilage from the diaphysis (see chapter on Miscellaneous Lesions)

Typhoid Fever is sometimes known to have arthritis as a complication, and the old text books used to say that it became purulent, and sometimes led to subluxation of the joint It is probably rare now, but "typhoid spine" or spondylitis occurs, and sometimes sets in some weeks after the fever is over Pain and tenderness appear



FIG 181

X ray of the pelvis showing secondary deposits from a case of carcinoma of the prostate This picture is shown for comparison with the X rays of Paget's Disease

over the spine with limitation of movement, and this may be accompanied by weakness and wasting of muscles The pains may radiate round the body If the condition is not treated early, kyphosis develops and the case may be mistaken for a tuberculous one The Widal reaction is usually positive

ALLERGIC FORMS OF RHEUMATISM

Rolleston once defined idiosyncrasy as an unusual physiological personal equation Allergy could be defined as a chemical idiosyncrasy On that rather non-controversial basis, hypersensitivity can be divided into anaphylaxis, a state found in animals, and allergy, found in man

Anaphylactic shock is a syndrome which is only constant in a particular species for instance, the features in dogs are a fall of blood pressure and the coagulability of the blood is diminished, in guinea-pigs asphyxia and emphysema, and in rabbits sudden heart failure

occurs in other bone diseases. However this may be, there is one great danger in the *localised type*, especially when confined to the pelvis—a tendency to develop osteosarcomata.

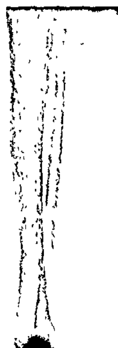


FIG. 180

Paget's Disease of the tibia.

If the X-ray is not decisive the diagnosis can sometimes be made by the estimation of *the blood* phosphatase. No great rise may be found in the acid phosphatase, but recent *figures* indicate that the alkaline phosphatase (pH 8·4–10·0) is often raised, even in extreme cases from an average normal of 7·3 units (King-Armstrong) to 245 units. The acid phosphatase (pH 4·5–5·0) is seldom materially raised in Paget's Disease, and may come to be used in the differential diagnosis as it is usually raised in prostatic carcinoma, especially with bone metastases. This condition is sometimes the alternative diagnosis. If this finding is confirmed it will be very useful, but Walkinson *et al.* (1944) are still somewhat uncertain whether their figures should be accepted as final (see chapter on Medical Diseases of Bone).

Paget's Disease of the local type gives rise to osteoarthritis of the hip and knee in a high proportion of cases.

Kyphosis and forward flexion of the neck is seen.

Many cases are discovered accidentally in the course of being X-rayed for other complaints.

Raynaud's Disease has been fully dealt with in the *chapter on* Peripheral Vascular Disorders. It only remains to mention that it is sometimes associated with a synovitis or an arthritis.

The matter of *Raynaud's Disease* has recently become topical, as in February 1946 Lord Justice Scott in the Court of Appeal held that workmen *operating* high-speed revolving electrical machines of a vibratory character receive multiple microtraumata which in their aggregate *amount to* injury of an industrial nature.

The details *of this* particular case are of a controversial nature and will not be discussed here, but we know from the X-ray changes which have been *found* in these workers that the bones themselves are affected, and therefore *as an a priori* case there seems no reason to doubt that the possibility of vascular damage is present.

Scurvy *is occasionally* associated with an effusion into the knee joint, but much more usually brawny swellings and purpuric spots are found in *and around* the popliteal space. In addition the hæmorrhages under the periosteum occur near the joints, and the limbs are so tender *that* the children cannot bear to be touched.

The *widening* of the epiphyseal line does not usually *affect the*

joint but in cases of *syphilitic epiphysitis*, crepitus and pain occur on moving the joints owing to the separation of the cartilage from the diaphysis (see chapter on Miscellaneous Lesions)

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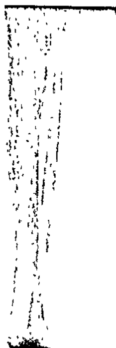


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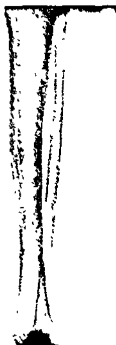


Fig 180

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If the X-ray is not decisive the diagnosis can sometimes be made by the estimation of the blood phosphatase. No great rise may be found in the acid phosphatase, but recent figures indicate that the alkaline phosphatase (pH 8·4–10·0) is often raised, even in extreme cases from an average normal of 7·3 units (King-Armstrong) to 245 units The acid phosphatase (pH 4 5–5·0) is seldom materially raised in Paget's Disease, and may come to be used in the differential diagnosis as it is usually raised in prostatic carcinoma, especially with bone metastases. This condition is sometimes the alternative diagnosis If this finding is confirmed it will be very useful but Walkinson *et al.* (1944) are still somewhat uncertain whether their figures should be accepted as final (see chapter on Medical Diseases of Bone).

Paget's Disease of the local type gives rise to osteoarthritis of the hip and knee in a high proportion of cases.

Kyphosis and forward flexion of the neck is seen.

Many cases are discovered accidentally in the course of being X-rayed for other complaints.

Raynaud's Disease has been fully dealt with in the chapter on Peripheral Vascular Disorders. It only remains to mention that it is sometimes associated with a synovitis or an arthritis.

The matter of Raynaud's Disease has recently become topical, as in February 1946 Lord Justice Scott in the Court of Appeal held that workmen operating high-speed revolving electrical machines of a vibratory character receive multiple microtraumata which in their aggregate amount to injury of an industrial nature.

The details of this particular case are of a controversial nature and will not be discussed here, but we know from the X-ray changes which have been found in these workers that the bones themselves are affected, and therefore as an *a priori* case there seems no reason to doubt that the possibility of vascular damage is present.

Scurvy is occasionally associated with an effusion into the knee joint, but much more usually brawny swellings and purpuric spots are found in and around the popliteal space. In addition the hæmorrhages under the periosteum occur near the joints, and the limbs are so tender that the children cannot bear to be touched.

The widening of the epiphyseal line does not usually affect the

joint, but in cases of *syphilitic epiphysitis*, crepitus and pain occur on moving the joints owing to the separation of the cartilage from the diaphysis (see chapter on Miscellaneous Lesions)

Typhoid Fever is sometimes known to have arthritis as a complication, and the old text books used to say that it became purulent, and sometimes led to subluxation of the joint It is probably rare now, but "typhoid spine" or spondylitis occurs, and sometimes sets in some weeks after the fever is over Pain and tenderness appear



FIG 181

X-ray of the pelvis showing secondary deposits from a case of carcinoma of the prostate This picture is shown for comparison with the X rays of Paget's Disease

over the spine with limitation of movement, and this may be accompanied by weakness and wasting of muscles The pains may radiate round the body If the condition is not treated early, kyphosis develops and the case may be mistaken for a tuberculous one The Widal reaction is usually positive

ALLERGIC FORMS OF RHEUMATISM

Rolleston once defined idiosyncrasy as an unusual physiological personal equation *Allergy could be defined as a chemical idiosyncrasy* On that rather non-controversial basis, hypersensitivity can be divided into anaphylaxis, a state found in animals, and allergy, found in man

Anaphylactic shock is a syndrome which is only constant in a particular species for instance, the features in dogs are a fall of blood pressure and the coagulability of the blood is diminished, in guinea-pigs asphyxia and emphysema, and in rabbits sudden heart failure.

occurs in other bone diseases However this may be, there is one great danger in the localised type, especially when confined to the pelvis a tendency to develop osteosarcomata.



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Anaphylactic shock is a syndrome which is only constant in a particular species for instance, the features in dogs are a fall of blood pressure and the coagulability of the blood is diminished, in guinea-pigs asphyxia and emphysema, and in rabbits sudden heart failure

These are the pattern reactions produced in each animal by *any* allergen

Many years ago it was found that the non-protein colloids were capable of provoking shock and this is generally referred to as "anaphylactoid" We now know that in both types of shock *histamine* is released and the different symptoms in the different animals are produced by this substance. The fact that histamine is only found in normal quantity in rabbit's blood can be accounted for on other grounds The liberation of heparin and cholin during anaphylactic shock has reduced the *problem to one which appears to* be primarily chemical, a suggestion which was made by Langdon-Brown many years ago (1932) We still do not know why anaphylactic shock stimulates the release of these substances. A very good example of anaphylaxis is quoted in the editorial of *The British Medical Journal* of March 4, 1944 (p. 33).

Allergy

The type of skin reaction whose characteristic is an *immediate wheal* and *erythema* is capable of *passive transfer* by means of the patient's serum on to normal skin (Prausnitz-Kustner phenomenon). *This indicates that certain antibodies, which in this case are usually* called "reagins," are present. This series of events is usually referred to "atopy" or "*atopic sensitivity*" Bacterial allergy as exemplified by the tuberculin reaction shows two great differences The skin response takes a *relatively long time* to develop (forty-eight hours), it is either *erythematous* or *necrotic*, and *passive transfer is not possible* It seems fairly clear that if allergy takes any part in the syndromes now to be discussed, the delayed or tuberculin type of reaction seems the only one which can possibly happen in the body cells.

Intermittent Hydrarthrosis

This condition is usually regarded as allergic.

The following case notes embrace nearly all the typical features.

M W Age 32 ♀ Typist

At the age of 18 the right knee suddenly swelled in the night, followed [illegible] little unusual) *They were blistered by* [illegible] Total incapacity 8 weeks

[illegible]

then gone down again The X-ray (taken at age [illegible] either knee E S R (Westergren) 10 m m. at the hour.

In between the attacks she can garden all day and not be tired

Sometimes the hydrarthrosis comes more often than this, in one case every 5 weeks and *lasting 5 days* *This case was in a male and* he arranged his life so that he could take 2 days off every 5 weeks He could tell the exact day the knee would swell and the day it would go down. He could go to the office the last 3 days *of the swelling if he* bandaged the knee and walked slowly.

frequently

Another form is said to go on to typical rheumatoid arthritis No experience of this is available.

The condition cannot be very common, as in 1921 there were only 77 cases in the literature, but it is diagnosed more often nowadays

Focal sepsis has been regarded as important, the hydrarthrosis being regarded as an allergic response It is possible but not likely that this is so, as no evidence of focal sepsis has been found in the cases seen

The *relationship to menstruation* is variable, some patients feel they can trace a connection, in the one case where this was carefully checked for two years the relationship was uncertain In one case the effusions ceased during pregnancy

The *allergic explanation* seems to be satisfactory up to a point The regular cycle of events, the failure to find any progressive patho-

space makes comparison with other conditions difficult Some authors have compared the syndrome to giant urticaria

Three synovial cell counts have averaged 700 cells per c mm , the smallest counts recorded in any joint trouble, if œdema was not present

Treatment is unsatisfactory *Autohæmotherapy* produced a remission of two years in one case but had no effect in others Some authors report cases due to food allergy, as mentioned before, this is unlikely *X-ray* treatment has been tried and ergotamine tartrate, 1 mgm a day by mouth. This is probably rather unwise *Physical therapy* is useful for maintaining the tone of the quadriceps if the knees show any loss of stability

The Arthritis of Serum Sickness is certainly allergic, and is probably due to an antigen-antibody reaction Eight to twelve days after the injection of serum a reaction may occur This is usually shown by an urticarial rash which is widespread over the body Temperature pain and swelling of the joints are accompanied by symptoms of shock Enlarged lymphatic glands often appear, either locally related to the site of injection or generally over the body Other rare symptoms are sometimes seen The delay of eight to twelve days may not occur and the whole syndrome may arise within a few minutes of the injection, especially if this is given by the intravenous route Death has been known to occur within a short time The joint phenomena are generally thought to be a form of anaphylaxis though some cannot regard them as true anaphylaxis The joints occasionally swell but more often are the site of heat and redness. Although they usually clear up within a few days, it may be three to five weeks before they are normal.

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Sometimes the hydrarthrosis comes more often than this, in one case every 5 weeks and lasting 5 days This case was in a male and he arranged his life so that he could take 2 days off every 5 weeks. He could tell the exact day the knee would swell and the day it would go down He could go to the office the last 3 days of the swelling if he bandaged the knee and walked slowly

Family history often includes other cases, in the case notes quoted a younger brother had "fluid on the knee" for the last two years, but the story was not typical of intermittent hydrarthrosis

Past history seems to include attacks of rheumatic fever rather frequently

Another form is said to go on to typical rheumatoid arthritis No experience of this is available

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The [illegible] less seem to consist mos[illegible] cardium with peri- arte[illegible] addition, *foci of* lym[illegible] cells *occur in the* connective tissue of the heart between the muscle fibres, round the arteries and blood vessels.

There is no doubt that the symptoms are of an allergic nature, and some of the arguments in favour of an allergic basis *in arthritis* have been based on these phenomena.

Unfortunately no other type of arthritis is known which can compare with that of serum sickness.

Palindromic Rheumatism

Hench and Rosenberg (1944) describe 34 cases of a syndrome which they had studied at the Mayo Clinic since 1928.

Somewhat like intermittent hydrarthrosis in the sense that it recurs at intervals, this syndrome has many differences. The recurrent attacks are afebrile the joints affected are red and hot, and although only one joint may be affected, many joints are sometimes painful. The period of disability varies from a few hours to a few days

The synovial fluid has shown an excess of neutrophils but does not always do so, although a fibrinous exudate sometimes remains at the end of an attack. Subcutaneous nodules were sometimes found but the histological pattern did not resemble that of rheumatic fever or rheumatoid arthritis

Laboratory investigations were entirely negative

Biopsy of synovial membrane showed acute inflammation many neutrophils but few eosinophils, and the collections of lymphocytes so stressed by Allison and Ghormley were not present.

Hench and Rosenberg were naturally much puzzled at what they found and were inclined to attribute an allergic origin to some of the features They could not identify their cases with urticaria (as has been suggested for intermittent hydrarthrosis) or with angioneurotic œdema. Foci of infection were few

Treatment is symptomatic Histamine has been tried with little success. Apparently the condition does not lead to chronic changes with the passage of time, nor do the intervals between attacks shorten These authors have not seen permanent changes follow in any joint

Painful Migrant Swellings

Not infrequently the physician interested in locomotor conditions is sent a patient, usually a woman, in the 40–60 decades complaining of temporary painful swellings which are noticed anywhere on the limbs but not as a rule on the face or trunk. They come every 3–4 weeks and last for about 5 days. At first small, painful and tender they gradually swell till they may be as much as 4 inches long and 2 inches wide. The hands are frequently affected Some of the

patients give a history of having taken one of the sulphonamides, others do not *Laboratory and X-ray* findings are normal

On some occasions the giving of an aperient overnight brings a crop of swellings, so high colonic irrigations were tried and in some patients this produced a crop of swellings in twenty-four hours The swellings are not cystic and œdematous only at the height of the attack, they undoubtedly lie in the subcutaneous and cutaneous tissue and they can disappear during the period of recovery in less than an hour by the watch Biopsy in one case showed the ordinary picture of the subcutaneous tissue with many round cells scattered through it but few eosinophils Skin tests were negative to routine substances, the usual bacteria and to sulphathiazole Over a period of two years one case has responded to no form of treatment and has gone to America to find a proper doctor who understands her complaint! This question may be bound up on the one hand with allergy or on the other with the problem of water balance

Quite apart from the question of malnutrition, it appears likely that the filtration force (particularly in the lower extremities) in the capillaries is either not balanced by the osmotic pressure of the plasma proteins, or sudden or perhaps gradual but long-continued rises of venous pressure upset it Although we have no proof it ever happens, it seems not unlikely that such a disturbance of equilibrium could affect one span of arterial distribution more than another and so produce local œdematous swellings This is perhaps a rather far-fetched explanation, but the only treatment which produces any result is the intravenous injection of hypertonic saline, and that only temporarily

Klinge (1929) tried to make some observations on the joints after intra articular reinjection of various substances such as protein He found an ulcerative arthritis and periarthritis with pannus formation destruction of cartilage and degenerative and proliferative foci in the

Klinge describes in great detail the joint changes in rheumatism and concludes most of them could be produced by hyperergic reaction on the part of the tissues

Another type of case which may represent allergy due to focal sepsis

L G Age 44 ♀ H W

In the past this patient had suffered from angioneurotic œdema, and after administration of a vaccine made of various allergens developed giant urticaria Recurrent attacks occurred at intervals Four years later [illegible]

swollen and tender Sulphonamides were ineffective but ephedrine ½ gr t d s improved the condition E.S R fell from 24 to 8 m m at the hour (Westergren) 5 per cent of eosinophils occurred in 9,600 white blood cells per c mm Infected tonsils removed, and recovery complete without relapse three years later

There are many points about this case, especially the swelling of the muscles, the effect of ephedrine and the past history, which make an allergic explanation likely.

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CHAPTER XXV

MISCELLANEOUS LESIONS

Fluorosis

IN 1942 Kemp *et al* published some cases which they called spondylosis deformans, and they tried to relate their findings to fluorine intoxication, but they could only conclude the fluorosis might favour its development

In 1943 Linsman and McMurray published the first case in America with post-mortem reports Unfortunately, the findings in their case are somewhat difficult to interpret, as in addition to the effects of fluorosis both kidneys were severely damaged and one was the site of a pyonephrosis It is uncertain whether this was secondary to an infected wound following sternal puncture or to the fluorosis Further, the serum calcium figure was 9 0–10 0 mg per 100 c c and the plasma phosphorus 8 2–8 5 mg per 100 c.c This failure to relate the two figures, and the raised phosphorus figure can be explained on the basis of kidney damage and need not be related to the fluorosis In spite of this, fluorosis was proved by bone analysis, the "mottled enamel" was present in the teeth and the secondary anæmia was present The pelvis, entire spine, scapulæ and clavicles all showed greatly increased density with a chalk-like appearance

It is generally thought that apart from the intoxication which fluorosis produces it is able to precipitate calcium salts stored in the body, and that this, in time, will reduce serum and tissue calcium to a dangerous level This view is supported by the fact that in areas of endemic fluorosis, onset of bone change can be delayed or even prevented by taking a high calcium diet

It seems certain now that the use of drinking water with a content of 5 p p m of fluorine may, after many years produce the skeletal changes described Very much the same conclusions were reached by Shortt *et al* (1937) in India and Ockerse (1944) in South Africa

diagnosis is made depends in the first place on the presence of mottled enamel, and a story of residence in an area of endemic fluorosis

Kemp *et al* published the first case in England and investigated both adults and children and found eight cases with severe dental fluorosis and disturbance of ossification

It seems that the best method of preventing fluorosis is the administration of an adequate diet with plenty of calcium It is now suggested that extra milk should be provided for industrial workers subject to the risk of fluorine intoxication

Calcinosis is usually divided into the general and local form

The *generalised form* may occur in either sex and fascial lines may be infiltrated with calcium deposits and they may even invade



FIG 182

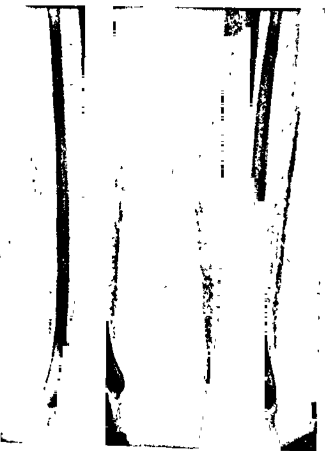


FIG 183

Calcinosis in a case of chronic nephritis with secondary hyperparathyroidism (Drs Wigley and Hunter)

By permission of the Honorary Editors of the *Proceedings of the Royal Society of Medicine*

tendon sheaths If the skin breaks down the deposits may come through. Laboratory investigations are all normal. Parathyroidectomy has not proved useful and treatment is symptomatic. The outlook is poor

The *localised form* (circumscripta) is usually only found in the fingers of the hand, round the knees and elbows A case has been reported (Wigley and Hunter, 1945) associated with chronic nephritis and secondary hyperparathyroidism

THE OSTEOCHONDRITIDES AND ALLIED CONDITIONS

Osteochondritis affecting the tarsal scaphoid (Köhler's Disease) has been described in the section on the foot

The type affecting the hip (Perthe's Disease) is dealt with in the section on osteoarthritis.

There remain the following entities

Osgood-Schlatter Syndrome is regarded by some as due to an osteochondritis This seems hardly likely and the avulsion of the tibial tubercle by the quadriceps tendon is probably a traumatic affair Nevertheless some authorities disagree entirely with this view

Kienbock Type is a true osteochondritis affecting the semilunar bone of the carpus

Apophysitis of the Calcanean Bone is due to sclerosis and fragmentation of the nucleus of the calcanean apophysis This is a cup-shaped affair situated over the tuberosity of the os calcis It occurs in children between the ages of eight and twelve and leads to pain in the heel at the back It is usually a self-resolving lesion

Freiberg's Syndrome is due to an epiphysitis of the head of the second metatarsal. The X-ray changes here are typical but difficult to read The articular surface of the head of the bone becomes straight instead of convex, spots of sclerosis appear in the sub-chondral bone, the shaft of the bone looks wider than normal and occasionally osteophytes appear Sometimes with rest and special boots the condition resolves but operation is sometimes required, the head of the bone being excised by the surgeon Some of the results [illegible] dritis [illegible] nosis [illegible] one vertebra is affected, that the body becomes wedge-shaped but that the intervertebral discs are normal

Kümmel's Disease is closely connected but occurs in adults It is usually traumatic in origin, and tends to run a protracted course

Syphilitic Osteochondritis (Parrot) is really an epiphysitis of congenital syphilitic origin. It is only found in infants and has already been mentioned The upper limbs are more commonly affected, and the X-ray shows an irregular epiphyseal line and periosteal thickening If the epiphysis becomes separated the condition is sometimes referred to as Parrot's pseudoparalysis. If the condition is diagnosed, treatment is adequate unless the growing line has already been damaged

Adolescent Kyphosis (Scheuermann's Disease) apart from the clinical signs shows some typical X-ray signs The vertebræ show *notches in their anterior surfaces.*
years they usually disappear afte
plates are irregular, if the nucleu
ing of the intervertebral space an
anteriorly. This gives rise to some kyphosis. In some X-rays Schmorl's nodes indicating nuclear prolapse into the vertebral body can be seen, but Schmorl's nodes occur in a number of spines which are symptomless and not deformed. Wedging of the vertebræ leads



Fig 184

The end result of a case of adolescent kyphosis The kyphosis and scoliosis have resulted in a great deal of disability.

to further kyphosis. In some cases the notches named after Scheuermann on the lower and anterior portions of the vertebral body are present

The *ætiology* is concerned with posture and the effect of obesity, but in addition there clearly must be some added factor such as epiphysitis or osteochondritis

Symptoms usually appear at the age of ten to fifteen years, but a great many cases are symptomless and appear at hospital in the

the Apprentice's kyphosis (Burns and Ellis, 1937) and some of the most difficult examples belong to this group.

The *treatment* is mainly orthopædic and the surgeon should be consulted early.

Osteochondritis Dissecans is an interesting malady characterised on the X-ray by a " ... ache
so formed is filled ... been

dislodged. The edge of this piece of cartilage can usually be clearly seen as there is a tiny space between it and the "cup" in which it [illegible] to an aseptic necrosis It is [illegible] e joint, but the hip joint, the

Treatment with physiotherapy may be tried but as the piece of cartilage mentioned is in fact a "loose body," and a fairly large one at that, ambulant treatment is not very desirable. Personal experience is that surgery with removal of the loose body is satisfactory. The danger of relapse must be considered, but does not often occur

Osteochondromatosis consists of the formation of many loose bodies composed of bone and cartilage They are usually numerous and can sometimes be palpated through the skin It is said that they are formed by the synovial villi As has been mentioned previously, it is now thought that this may be a possibility. So many loose bodies are present that they damage the joint still further and so are better removed surgically. The condition is rare.

Bell's Palsy (*facial nerve*)

It is always unsatisfactory and sometimes dangerous to take one particular aspect of a subject and divorce it from its real and proper surroundings. A brief description of Bell's palsy is added here because it is so often sent to physicians specialising in locomotor disorders, and it is right to emphasise the traps attaching to such a procedure

Bell's palsy is an infranuclear idiopathic paralysis of the seventh nerve. If the facial nerve is affected in its supranuclear portion, the lower face only is affected The reason for this is that that part of the facial nucleus which supplies the upper face (e.g. the forehead) receives pyramidal fibres from *both hemispheres*, whilst the part supplying the lower face receives fibres only from the contralateral hemisphere In Bell's palsy the whole of one side of the face shows evidence of paralysis This sign by itself, however, is not evidence of an idiopathic causation and the most meticulous examination is required

Pointers in the Diagnosis

If the lesion *is within the pons* it is usually associated with a sixth nerve palsy, accompanied by diplopia and paralysis of the external rectus If the pyramidal fibres are caught, an extensor plantar response will be found *Between the pons and the internal auditory meatus* there may be associated deafness, and the usual cause is a neurofibroma of the eighth nerve, but any local lesion may be responsible Within the *aqueduct of Fallopius* the lesion is associated with loss of taste on the anterior two-thirds of the tongue from involvement of the geniculate ganglion and its connection with the chorda tympani. Emotional movements are also lost Any form of neuritis, meningitis, or bony involvement may be the cause *After the nerve has*

Adolescent Kyphosis (Scheuermann's Disease) apart from the clinical signs shows some typical X-ray signs. The vertebræ show *notches in their anterior surfaces* Although these are normal in earlier years they usually disappear after infancy. The vertebral cartilage plates are irregular, if the nucleus pulposus escapes there is narrowing of the intervertebral space and the articular hinge tends to close anteriorly This gives rise to some kyphosis. In some X-rays Schmorl's nodes indicating nuclear prolapse into the vertebral body can be seen, but Schmorl's nodes occur in a number of spines which are symptomless and not deformed Wedging of the vertebræ leads



FIG 184

The end result of a case of adolescent kyphosis. The kyphosis and scoliosis have resulted in a great deal of disability.

to further kyphosis In some cases the notches named after Scheuermann on the lower and anterior portions of the vertebral body are present.

The *ætiology* is concerned with posture and the effect of obesity, but in addition there clearly must be some added factor such as epiphysitis or osteochondritis

Symptoms usually appear at the age of ten to fifteen years, but a great many cases are symptomless and appear at hospital in the fourth or fifth decade complaining of pain and disability. The dorsal spine is generally affected. Schanz described an interesting type due to carrying excessive loads on the back and shoulders. He called it the *Apprentice's kyphosis* (Burns and Ellis, 1937) and some of the most difficult examples belong to this group

The *treatment* is mainly orthopædic and the surgeon should be consulted early.

Osteochondritis Dissecans is an ... ...iced on the X-ray by a "scooping out" so formed is filled with the small

dislodged The edge of this piece of cartilage can usually be clearly seen as there is a tiny space between it and the "cup" in which it lies. This appearance is probably due to an aseptic necrosis It is most often seen in girls and in the knee joint, but the hip joint, the elbow and the ankle can all be affected

Treatment with physiotherapy may be tried but as the piece of cartilage mentioned is in fact a "loose body," and a fairly large one at that, ambulant treatment is not very desirable Personal experience is that surgery with removal of the loose body is satisfactory. The danger of relapse must be considered, but does not often occur

Osteochondromatosis consists of the formation of many loose

bodies are present that they damage the joint still further and so are better removed surgically The condition is rare

Bell's Palsy (*facial nerve*)

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issued from the stylomastoid foramen voluntary and emotional movements are lost. It is well to remember that a parotid tumour may be at the bottom of this.

The condition has been called idiopathic because the *ætiology* is unknown, but so many cases are associated with exposure to cold that some sort of "rheumatic" basis is postulated such as an interstitial neuritis of the nerve itself, or a "fit

When the diagnosis is establis wire mask should be used to hold *stretching* of the muscles The eyes must be cared for. Galvanism and massage are sometimes useful, if re-education is practised at the same time.

These cases should be referred for a neurological opinion, as a good many diseases of the cerebrospinal system have a seventh nerve palsy as one of their complications



FIG 185

A case of Tietze's Disease—note the swelling above, which is connected with the first costal cartilage and comes out by the sternoclavicular joint The second swelling is situated over the second rib on the left side.

Tietze's Disease consists of non-suppurative swellings of the costal cartilages (usually 1, 2 and 3), which gradually increase in size Gill *et al.* (1942) reported five new cases and reviewed the scanty literature In those cases there was no evidence of bone disease.

The swellings are often associated with respiratory affections, but it may be many months (or ? years) before they clear up. *Microscopical examination* of the cartilages shows irregular chondral tissue but no other evidence of malignancy. Apart from this the sections are usually normal.

The syndrome is described here as it can be confused with swelling of the sternoclavicular joint, which is sometimes gonococcal and sometimes due to rheumatoid arthritis.

Treatment has little effect, but the swellings can be excised.

Pellegrini-Stieda syndrome consists of a hæmorrhage round and

about the medial lateral ligament of the knee under the periosteum of the femur. Presumably due to trauma, calcification occurs in the hæmatoma Rest and heat seem to do good, but possibly surgical interference might be called for in severe cases

Caisson and Pneumatic-tool Workers have been subject to certain forms of locomotor disorder

If decompression takes place too rapidly in the caisson nitrogen bubbles become released in the blood and infarction of bone (and other tissues) may occur. It is said that if infarction takes place at or near the epiphysis and the articular edge, the joint cartilage necroses and is replaced by fibrocartilage. The X-ray will show the infarct, and a secondary osteoarthritis develops.

Workers with pneumatic tools tend to develop areas of decalcification in the wrist and carpus Some of these cases also suffer from numbness and paræsthesiæ.

Painful Fat

The question of obesity in its relationship to osteoarthritis has been fully reviewed and for detailed information reference should be made to the original work (Fletcher, 1939), which has been mentioned in the chapter on the Ætiology and Pathology of Osteoarthritis

Painful fat has been mentioned in the chapter on Fibrositis, and Copeman has referred to his original work on the subject Panniculitis is also mentioned and the condition sometimes referred to as "adiposis dolorosa juxta-articularis," in which painful pads of fat are found on the medial aspect of the knees and elbows This condition is sometimes confused with arthritis Copeman's theory of a shift of extracellular fluid into the fatty tissues is a comparatively new one, but is not necessarily inconsistent with the idea that this is just one form of hypothalamic-pituitary adiposity. In fact, treatment with ammonium chloride and mercurial diuretics would fit either theory and is quite useful Thyroid extract is usually added to this régime Some attempt is also made to deal with the depressed psychological outlook.

A special form of panniculitis occurs as a relapsing febrile disease and is sometimes referred to as the **Weber-Christian Disease.** Apart

of these deposits may lead to areas of depression and subcutaneous atrophy Mild arthralgias accompany the relapses *Biopsy* showed fat necrosis The differential diagnosis is usually easy

Myositis

Myositis is undoubtedly a rare condition

The generalised type is sometimes referred to as a polymyositis.



FIG 186

To show the adhesions to the skin in panniculitis of the juxta articular type.



FIG 187

A case of adiposis dolorosa juxta-articularis



FIG 188

An advanced case of panniculitis.

This may be due to any of the usual pyogenic bacteria, or may follow any of the infective fevers The usual constitutional symptoms of an infectious process are in evidence, the affected muscles are hard and tender Occasionally the superjacent skin becomes involved and erythematous. Local abscess formation may occur.

Dermatomyositis is the term used for the syndrome when the erythematous skin goes a stage further and urticarial or purpuric rashes are observed. Erysipelas may occur The cutis becomes so hard and tough it cannot be lifted off the subcutaneous tissue

inflamma-

s

with little pain but a gradually increasing stiffness, weakness and loss of weight The *muscles* feel rather like putty, and gradually get harder and

become the seat of contractures, and the disease marches to a fatal termination in some months or years Creatine metabolism is said to be upset

Treatment is symptomatic

The localised type may be somewhat similar but confined to one group of muscles *Gonococcic myositis* is generally of this nature

Myositis Ossificans also has a *general* and a *local* form

The general form is often called **Myositis Ossificans Progressiva.** It starts in early life, Garrod's case being five months old The signs are swelling, pain, fever and œdema with local swelling This clears up and there may be a pause of some months before the next attack starts in the same way Gradually the sites attacked become more numerous, and as they resolve they calcify The process generally starts in the back or neck, and complete crippledom is the final result *Microdactyly* is a feature in two-thirds of the cases Creatinine and uric acid excretion are diminished

The local form is quite different It is due to trauma, and a muscle sheath may be torn allowing bone cells to enter, they form a bony tumour This ossific process may extend along the fascial planes

Sub-varieties of the same process are well known, bony formation in tendons giving rise to such conditions as rider's bone (adductor longus) These deposits are seldom or ever absorbed

Human Creeping Myiasis has been reported in this country (Turner, 1945) A boy aged fourteen who had never been out of the country had "pricking" pains over the shoulders and chest, accompanied at a later date by swellings which appeared, lasted a few days and then disappeared These were found at different times over the shoulder, back, and the back of the head and neck A feeling of something moving under the skin accompanied them. Finally one of these swellings came up on the right thigh, was fomented and

discharged a small maggot An eosinophilia of 54 per cent. was found in 22,000 white cells per c.mm.

On another occasion the maggot was identified as the larva of the warble-fly (*Hypoderma bovis*) This unusual syndrome (only five cases recorded) is of great interest as the *muscle pains form a feature* in the early stages.

Paroxysmal Proctalgia consists of pain starting in the rectum, relieved by defæcation It usually occurs at night and is associated with shock

Ætiology is unknown, but the syndrome usually occurs in males *Treatment* is ineffective.

Vascular Myelosclerosis is seen in the aged and is accompanied by pain, stiffness, weakness and atrophy The process is a gradually progressive one and some say there is an accompanying arterio-sclerosis in the basal ganglia. Flexion deformities are usual The disease is not very [illegible]

Trichiniasis pre[illegible]

of eating half-cook[illegible]

with the nausea, vomiting and diarrhœa which followed will usually give the clue. Unfortunately some patients give no history of this kind In these circumstances recourse must be had to skin-testing *with the specific antigen, as it is essential to deal with the condition* before the muscles become irrevocably invaded. Trichiniasis may be found accidentally in the course of an X-ray examination for some other complaint, so some part of its course may be asymptomatic

Tendovaginitis

De Quervain described a condition which he called stenosing tendovaginitis at the radial styloid in *1895. It usually occurs in* the thumb as originally reported. "*Trigger finger*" and "*snapping finger*" probably belong to the same group.

It is more common in females The syndrome is pain in the thumb on abduction and the presence of a visible swelling over the styloid process, which is tender. The pain is due to the extensor tendons becoming stuck under the posterior annular ligament *Surgical treatment* with partial excision of the thickened sheath is curative

Trigger finger is due to the same pathological basis It occurs mostly in women and is sometimes associated with a lump over the *metacarpophalangeal* joint of the finger. From the flexed position the patient is unable to straighten the finger without help.

Snapping finger or thumb is practically the same condition with the same background, but a snap is heard as the tendon to the finger or thumb is moved

Sudeck's Atrophy is an interesting condition, the pathology of which is not understood. Generally, but not always, it follows *trauma, and consists of rarefaction and osteoporosis* of the bones near the site of injury. Usual sites are hands and feet, forearms and legs. Pain may be very substantial and vasomotor symptoms may be coupled with trophic changes in the overlying skin

Conservative measures such as physiotherapy and *immobilisation*

should be tried for a considerable period Some authors recommend sympathectomy but the physiological basis is not really sound

Tenosynovitis occurs most commonly after trauma, but another very common cause is *gonorrhœa* The traumatic type is painful and most commonly occurs in the supraspinatus tendon or the quadriceps tendon. The hand may also be affected

The *tuberculous and syphilitic* cases are uncommon and usually painless

In most cases of tenosynovitis an audible crackle can be heard over the affected tendon with a stethoscope when the muscle is used

Treatment depends on the prime cause, but in most cases complete immobilisation in plaster is required

Bursitis may occur in any of the innumerable bursæ in the body The common sites of bursitis are the olecranon, subdeltoid, prepatellar,



FIG 189

Semi membranosus bursitis

trochanteric and semimembranosus bursæ, occasionally the buttock bursæ over the ischial tuberosities are affected *Trauma* is the great cause of prepatellar bursitis the old "housemaid s knee"

Subdeltoid bursitis has been dealt with in the chapter on the Shoulder Joint

Semimembranosus bursitis (Baker's cyst) is not very common. This bursa is situated between the medial head of the gastrocnemius and the semimembranosus It is continuous with the capsule of the knee joint Some authors regard it as a herniation of the synovial membrane It is more likely that the cyst is an enlarged bursa with a cellular lining, but it certainly communicates with the joint on many occasions when it is enlarged

The *olecranon bursa* has one peculiar feature, it is often enlarged (but seldom tender) in gout Cholesterol crystals are easily deposited in the bursæ It is seldom a great disability

Ganglia are important because they are so common. It is well to remember that ganglia never communicate with a tendon sheath or a joint. They are but a slight disability, but can be dispersed by a

sharp blow with any heavy book. The "family Bible" used to be regarded as the weapon of choice. Unfortunately they recur, but the injection of sclerosing solutions has no better result. Surgical removal hardly seems worth while unless they appear in a very inconvenient site. Even after operation they sometimes re-form. They can be closely imitated by certain synovial protrusions found in the course of rheumatoid arthritis.

Locomotor Neuroses are, rather naturally, fairly usual. Patients

In addition to this, muscular tension is, as is well known, a very ordinary way of exhibiting mental tension, and muscular tension, especially at unusual angles, is a ready way of producing minor locomotor difficulties.

Posture itself is merely an expression of muscle tension in different groups of muscles, and posture is a thing we must maintain all our sitting and standing days Postural fatigue, especially if the posture be somewhat unnatural, is easy to come by, and without gross anatomical abnormalities may be the origin of real pain and distress The question of the level at which pain comes into consciousness is one which absorbs clinicians in every field, but in no field, perhaps, so urgently as in the field of locomotor disorders. No explanation of this is forthcoming, because we cannot look into the hearts and minds of men and women and judge their reactions to stimuli by a yardstick with which we are familiar, or our reactions to the same stimuli

At the present time, our answer to these difficulties must be that we shall judge the physical value of our patients' complaints in the light of our objective findings. By this road progress lies, for in the field of locomotor disorders, as much as in any other, physical signs must be the arbiter and final mediator of our opinion. It cannot be denied that some small injustice will be done to some patients, and that is the measure of our ignorance. Against that we must set the immeasurable good we shall do by checking at the onset innumerable candidates for the field of psychological medicine.

The *lateral cutaneous nerve* of the thigh arises from L1 and 2, and passes into the thigh almost directly under the anterior superior spine of the ilium, where it divides, and the anterior branch is sometimes enclosed by an invagination of the deep fascia. Here it may be compressed and pain of a very severe nature will be felt in the front and side of the thigh. The syndrome is quite characteristic, and one of its characteristics is that it attacks males more than females and so has been encountered with some frequency during the late war. Occasionally the pain becomes so severe that surgical interference may be called for. Sometimes, however, the nerve may be injected with good results The landmark is a point one fingerbreadth below and medial to the anterior superior iliac spine and 1 per cent. procaine is injected, after the needle has been thrust through the skin perpendicularly. The iliac bone is generally met by the

needle, and this is the signal for injection It is as well to move the point of the needle about so as to distribute the injection and about 10 c c. will be required

There are special techniques for neuralgia of other individual nerves These are mostly uncommon and special text-books should be consulted.

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symptoms as a criterion, it seemed advisable to separate the patients into two groups: (A) those with symptoms for less than a year, and (B) those with symptoms for more than a year. The average age for Group A was 7 months and for Group B 4·7 years. This appeared to be a significant difference and it seemed likely that this grouping might be useful in separating the patients as regards sex, age, treatment, or prognosis. Actually this is not so, for Group A differs from Group B in none of these factors; the two groups are worth bearing in mind, as some differential factor may eventually be found.

TABLE I

ANALYSIS OF CASES BY AGE AT ONSET OF SYMPTOMS AND AGE AT TIME OF DIAGNOSIS

Age at onset of symptoms (years)

Sex	10–20	20–30	30–40	40–50	50–60	60–70	*Total*
Males	4	18	16	7	5	4	54
Females	5	8	8	9	4	2	36
Total	9	26	24	16	9	6	90

Age at diagnosis (years)

Sex	10–20	20–30	30–40	40–50	50–60	60–70	70–80	*Total*
Males	1	16	15	12	5	5	0	54
Females	3	6	12	6	7	1	1	36
Total	4	22	27	18	12	6	1	90

Sex Incidence

It has usually been stated that this is a disease predominantly of males. Of 150 cases quoted by Buckley only 20 were in females (13 3 per cent) In the original series of 68 cases (Fletcher, 1944) there were 32 females and it was stated at the time that no explanation of this difference could be offered. In the present series of 90 cases (including the original 68) there are only 36 females, so that in the last 22 cases seen only 4 females have appeared (18·1 per cent. as against 47·1 per cent.). This is a substantial difference, but may be accounted for by the fact that a larger number of soldiers are included in the last batch of cases. It is at any rate quite evident that the sex incidence is very different from that found in rheumatoid arthritis, where females predominate to such a marked extent. Lumbar incidence is far more common in young males (see Fig. 194).

Occupation

It has been said that cases of ankylosing spondylitis are drawn from the ranks of sedentary and "protected" workers. In this series,

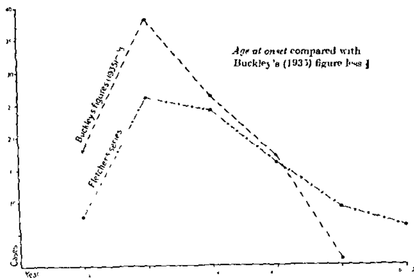


FIG. 192

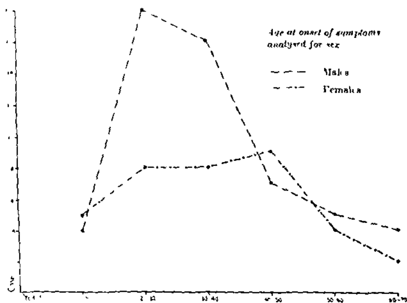


FIG. 193

of the males 24 did manual work and 30 had sedentary occupations Division of women into such groups is difficult and misleading, but of 36 females, 13 were housewives, 8 domestic workers, 3 nurses and

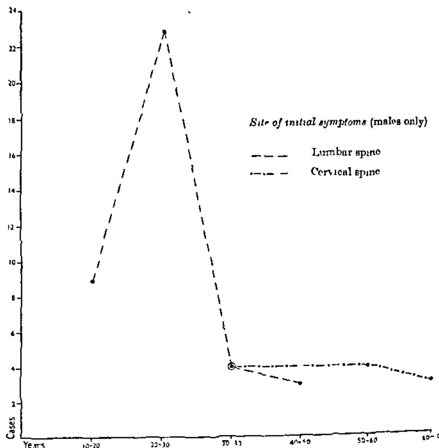


Fig 194

12 office workers. So far as any opinion can be expressed, the influence of occupation seems to be doubtful

The Causation of the Syndrome is unknown. In 90 cases antecedent or concomitant factors were:

	Cases
Gonococcal infection	2
Trauma	4
Infection of teeth and tonsils	12
Rheumatic fever	7
Pulmonary tuberculosis	8
Pneumonia	3
Pregnancy	1
Menopause	2
Hyperpiesia	3
Sprue	1
Diabetes	1
Repeated fractures	1

One patient had a remission for seven years after the stump of a tooth was extracted.

In the 70 cases tested 4 positive Kahn or Wassermann reactions were found. Of 53 gonococcal fixation tests 5 were positive and 1 mildly positive. Few ætiological factors stand out as having unusual frequency.

Rheumatic fever (7 7 per cent) probably occurs somewhat more frequently than it would by chance Buckley included "generalised rheumatism" in his estimation of this factor and found an incidence of 14 per cent , but he found valvular disease in many of them

Gonococcal infection was thought to be a factor for many years. In this series 2 cases were found, one active and one of apparently little consequence (2 2 per cent). In Buckley's series 10 cases were found (6 6 per cent.) Although sound opinion supported the gonococcus as a cause for so long, there is no support for this view at present

The position of *pulmonary tuberculosis* is somewhat different In the first 68 cases it occurred only 3 times, but in the last 22 cases it occurred 5 times (8 8 per cent) This by itself would be of little account, but the clinical impression is left that in these 8 cases the tubercle bacillus seemed to be more than merely coincidental

Robinson (1940) found that the *tuberculin sensitiveness* of 45 patients with ankylosing spondylitis was 30 per cent higher than that of 90 rheumatic control cases So as to check the tubercular specificity of the tuberculin skin reaction, the tuberculin complement fixation test as to the presence of actively antigenic tubercle was used This is probably accurate up to 80 per cent It seems likely from the results obtained that the tuberculin sensitivity so demonstrated may not be specifically tubercular This evidence, somewhat ambiguous though it may be, is of considerable interest, and the opinion can be expressed that the nearest relationship to other syndromes may be found in pulmonary tuberculosis To this should be added the fact that the so-called "sacral focus" (presently to be described) may be indistinguishable (in its unilateral form) from tuberculosis of the sacro-iliac joint When pulmonary tuberculosis is associated with ankylosing spondylitis the spondylitis usually precedes the tuberculosis

No clinical case of *hyperparathyroidism* has been encountered in the present series of cases Ssamarin (1928) advocated parathyroidectomy, but it is clear from the results of other authors that there can be no sound basis for such an operation

PATHOLOGY

Pathology of the disease can be divided into two parts, that of the sacro-iliac joints and that of the spine

The *sacro-iliac joint* Although biopsies were taken from this joint some years ago, no pathological information has become available It seems clear that the reading of bone pathology is still in its infancy, and so we depend on the radiographic changes.

The *spine* shows fairly constant change, but most descriptions

are confined to *late changes*. Here the ligaments of the spine are calcified, the vertebral bodies are joined together and the apophyseal joints may be ankylosed. The intervertebral discs are joined by bony tissue at their circumference, but in the centre they are free. Some of the ankylosed joints show bony ankylosis and presumably this was what Pierre Marie meant when he referred to ossification of the spine. Curiously enough the spinal canal is always kept clear and so are the vertebral foramina. Rarefaction of bone is the rule.



FIG 195

The earliest stage of calcification of ligaments.

PHYSICAL SIGNS

Posture is important. The forward flexion of the neck with the accompanying kyphosis may be noticed, if looked for, even in mild cases

Stiffness of the spine is shown by a positive forward bending test and is in many cases the earliest physical sign. *Chest expansion* is sometimes restricted at an early stage. The *lateral bending cervical* test may be positive much later, especially in men.

The painful *pelvic twist* (done very gently) is an early sign in men and late in women.

Evidence of involvement of shoulders and hips may come either early or late, but on the whole when the process has been advancing for some time

Marked loss of weight may occur, but suggests pulmonary tuberculosis. Chest X-rays should be taken in all cases

MANNER OF ONSET

The onset of the disease may occur in various ways and it is wise to study these initial symptoms carefully as they can be very misleading Pain and stiffness often go together.



Fig 196

Showing the early appearances of ankylosis of the lateral spinal joints This picture was taken after a biopsy of the sacro iliac joint

The Initial Symptoms

Girdle pain was the initial symptom in 48 cases, 13 had cervical pain radiating down the arms, 7 had pain over the dorsal spine radiating to the epigastrium (3 of these had been treated for indigestion). 22 complained of lumbar pain radiating to the abdomen, and 14 had sciatic radiation

Pain in the back was the initial symptom in 32 cases In 11 of these the cervical region was affected in 4 the dorsal region, in 13 the lumbar region, in 2 cases the sacral region, and there was a double incidence in 2 cases

Pains all over the body are usually referred to muscles. Common sites are the trapezii, the muscles of the thigh and the calf muscles The muscles are often tender and the usual diagnosis is fibrositis, although thigh and calf muscles are not common sites for this complaint. Four cases started in this way.

Pain referred to peripheral joints as an initial symptom makes the diagnosis difficult In this series four cases started like this and in



Fig 197

The earliest stage of involvement of a hip joint At this point the hip was severely limited in movement

two more swelling of a knee or an ankle with effusion was the first symptom

RADIOLOGY

Campbell Golding (1936) and Gilbert Scott (1942) have both published work on the radiological aspect In the great majority of cases (probably over 90 per cent) the first radiographic changes are noted in and around the sacro-iliac joints In some cases, but probably not in all, spinal changes follow.

The **Sacro-iliac Joints** are frequently the site of congenital

variation, but it is useful to have knowledge of the normal joint. It is divided into two parts, the upper or fibrous compartment and the lower or cartilaginous part. In the *fibrous part* the opposing surfaces are highly irregular, and are bound together with many strands of tough fibrous tissue. In the *cartilaginous part* the state of affairs is quite different. Here cartilage covers both surfaces of the joint, and a true joint exists with a little synovial fluid.

Radiographically these two portions can be distinguished. The joint appears as an inverted pear, the stalk being the fibrous portion and the pear the cartilaginous portion. This part is outlined by the anterior and posterior fissures.

The changes found in these joints in ankylosing spondylitis are variously referred to as sacro-iliitis or the "*sacral focus*."

Scott describes well the changes found and the order in which they occur.

1. *Loss of definition of the anterior and posterior fissures.*—This must be one of the earliest changes, as this change alone is never seen.
2. *Broadening and irregularity of the whole joint.*—This is probably the second change in order of time. As the joint space broadens the edges become crenated and a very narrow band of sclerosis may appear along its whole length.
3. The *narrow band of sclerosis* gradually spreads out into the bone.
4. The last stage is usually that of ankylosis. This occurs either with or without extensive rarefaction of bone. Sometimes *these changes are unilateral* and in this case the diagnosis may for a time be difficult or even impossible. The differential diagnosis is tuberculosis of the sacro-iliac joint, and the appearances are very similar. A point which occasionally helps is that there often are small cavities present round the joint in tuberculous disease. These are never seen in the sacral focus. On one occasion the diagnosis was in doubt for a year. Eventually the case turned out to be tuberculous. The formation of a cold abscess sometimes helps.

Other points which are useful are the formation of *new periosteal bone* round the ischial tuberosities and the calcanean bones, and rarely ankylosis of the symphysis pubis. These are not uncommon in ankylosing spondylitis but do not occur in every case. It seems fairly clear that the changes in the sacro-iliac joints may never spread to the spine.

The Spinal Radiographic Changes

These have been described many times and a brief description only will be given.

Calcification of ligaments is an outstanding feature. The *anterior common ligament* is usually involved early, but the ligamenta flava follows soon after.

The *interspinous ligaments* become calcified and it is difficult to be sure in an anteroposterior view whether the central line of calcification is to be found in the anterior common or interspinous ligament. The lateral film will usually reveal the anterior common ligament to be



FIG 198

A typical sacral focus in a case which developed pulmonary tuberculosis three months later.



FIG 199

A case of tuberculosis of the sacro-iliac joints in a nurse

involved. *Two lateral lines of calcification* are usually described, these are due partly to the ligamenta flava, but more especially to the involvement of the lateral spinal articulations A good deal of controversy exists as to whether these articulations become ankylosed at an early stage There seems little doubt that they do, but the appearances are confusing as the capsules of these joints become calcified and obscure the joints themselves. These joints become the seat of a synovitis with exudation into the joint, invasion of the cartilage by round cells and formation of fibrous tissue As the cartilage disappears, bony ankylosis ensues The costovertebral joints are similarly affected Some authors have stressed that much change may take place before it is shown on the X-ray. From what has been said in the chapter on Osteoarthritis of the Spine, this does not seem to be very likely *Rarefaction of the vertebral bodies* goes hand in hand with the changes described Calcification in the *short intervertebral ligaments* joining the edges of the annulus fibrosus in some cases, and the vertebral bodies themselves in others, gives the bulging appearance which brought the term "bamboo-spine" into use



Fig 200

The characteristic attitude of an early case

When the *limb joints are involved*, e g the hips and shoulders, the radiographic appearances are the same as those of rheumatoid arthritis In those cases, already mentioned, where the disease commences with swelling and synovial effusion in a medium joint, e g the knee or ankle, these joints show no radiographic change and generally clear up completely

Erythrocyte Sedimentation Rate

Taking 15 m m at the hour (Westergren) as the top limit of normality, 41 of the 54 males and 19 of the 36 females showed a raised figure. This corresponds to 75 9 per cent of males and 52·7 per cent of females If 10 m m at the hour is taken 49 of the 54 males and 25 *of the 36 females showed a raised rate The E S R is not of great* value in prognosis, some cases do well in spite of a rising figure and vice versa

Other *pathological* and *biochemical* investigations are as a rule negative Papers have been published from time to time suggesting that calcium metabolism is at fault and experimental hypercalcæmic arthritis has been produced in rats To all ordinary tests calcium and phosphorus metabolism appears to be normal and both acid and alkaline phosphatase values have been normal in this series.



Fig 201

A case of unilateral sacro-iliitis in a girl aged 17.



Fig 202

Lateral X-ray of the spine showing calcification of the anterior common ligament The calcification between the upper vertebræ is not continuous.



Fig 203

An unusual appearance rarely seen in neck in ankylosing spondylitis Note difference in joint space between C 4 and

Comparison of the Syndrome as seen To-day with the Descriptions of the Early Authors

The following table gives the findings in 90 cases of ankylosing spondylitis compared with the original classical descriptions of the disease.

Signs, Symptoms, History	*von Bechterew (1893)*	*Marie Strumpell (1897)*	*This Series*
Site of original symptoms	Cervical spine travelling downwards	Lumbar spine travelling upwards	Cervical 27, dorsal, 15, lumbar, 42, double incidence, 6
Kyphosis	Fixed dorsal	None, erect posture	In 34 of 90 cases = 37 7 per cent
Limb joints	Not affected	Always affected Often ankylosed	Ankylosed in 12 cases = 13 3 per cent
Muscles affected	Paresis and slight atrophy	Severe atrophy	Generalised atrophy in 35 cases 38 8 per cent
Spine	Infection of pia spinalis	Ossification of spine (Precise meaning uncertain)	'Bamboo spine' in 7 cases There is no evidence that this is a neurological disease
Antecedent and family factors	Heredity, trauma and lues	Rheumatism and infection	See under Ætiology

Comparison of present series with the classical types—It is clear that the disease to-day shows features of both the classical descriptions and it is uncertain why such acute clinical observers should have described only cases of one kind or the other. The discovery of the radiographic sacral focus no doubt has played a considerable part.

Cases without a Sacral Focus

Clinically, these cases resemble ankylosing spondylitis with a sacral focus. There were 5 women and 4 men and all pelvic X rays were carefully rechecked. The average age at onset of symptoms was 44 and at diagnosis 46. In 6 cases the onset was in the 40–50 age group. The site of attack in all the women was the cervical region and in the 4 men the dorsal region. *Occupation and ætiological* factors did not differ from those in the main group. The E S R was raised in 2 women and normal in 3, it was raised in all 4 men.

Radiography showed local ankylosis of the lateral spine articulations in 5 cases (4 women 1 man) and local calcification of ligaments in 4 cases (1 woman 3 men).

Of these 9 cases, 4 are under observation and 4 have been followed 2, 2½, 5 and 6 years after the patients were first seen. In these cases the sacro-iliac joints were still clear by X ray examination and the

original lesion showed no advance, but the clinical picture is still unsatisfactory, all 4 patients still complain of pain and disability One case cannot be traced and the other 4 are too recent for assessment to be useful.

These cases have already been discussed under osteoarthritis of the spine Some may belong to the group *spondylosis ligamentosa ossificans*, and not to the group ankylosing spondylitis. Others may represent cases of ankylosing spondylitis with an abnormal course

The Stage at which the Disease was first seen

Only 87 cases are included, in 3 cases the radiographs were not available for rechecking.

Using X-ray standards, the cases were distributed as follows.

Group		*Cases*
A	Sacral focus only	29
B	Sacral focus and involvement of the spine	17
C	Ankylosed sacro-iliac joint and involvement of the spine	32
D	Special group with clear sacro-iliac joints	9

No significant difference in sex distribution, sedimentation rate, age, length of history, treatment, or prognosis (so far as is known) could be demonstrated between any of these groups.

If a sacral focus always led to ankylosis, one would expect the cases with the sacral focus to have a shorter history than those showing ankylosis. They have; but the difference is very small and not significant. The significance of the remissions which occur is difficult to assess Nor has a sacral focus been seen to change to ankylosis though the investigation has been carried on for ten years, but there *is no doubt that the X-ray changes are slow, and moreover 30 cases* were originally seen in the ankylosed state. It is well known that the disease has a natural term in some cases; one patient seen originally with ankylosed joints has had no recurrence in twelve years.

Some authors have published X-rays of patients with a sacral *focus followed* by X-rays taken years later in which ankylosis is said

details. Of 32 cases of ankylosed joints in this series, 8 had clinical histories of less than a year, which suggests either that the disease may have a long silent period, or that ankylosis may take place very quickly.

The Course of the Disease is characterised by remissions and exacerbations. Pain and stiffness are always the leading symptoms. Atrophy of the erector spinæ group of muscles can become very troublesome It seems as if the muscles are in continuous spasm, and the weakness so engendered is coupled with a gradually increasing limitation of movement. *Ankylosis* of the costovertebral *joints* and the general rigidity of the thorax leads to respiration which is almost entirely diaphragmatic, and it is a wise measure to institute

breathing exercises early. As the *lumbar spine* becomes increasin stiff the normal lumbar lordosis is lost, and as the *cervical spi* becomes affected, turning of the body accompanies turning of th head The *dorsal kyphosis* has already been mentioned

Constitutional symptoms such as fever and tachycardia are seldom seen, but *loss of weight* is a marked feature in many cases

The *characteristic posture* with flexion of the neck, the kyphotic and stiff spine is well known

Although so serious and so disabling, ankylosing spondylitis is *not* as a rule *a lethal disease* If it shortens life it generally does so because of its effect on the thorax, the ribs tend to become fixed in expiration so that the filling capacity of the lung is adversely affected and pulmonary infections tend to occur because of the defective blood supply The somewhat indefinite tuberculous tendency has already been noted

It is as well to remember one important point, the *disease has a natural course* Whatever the state of affairs may be when this course has been run, will be that patient's state for the rest of his life There will be *no* betterment and no worsening so far as the disease itself is concerned It is therefore essential that his condition at that point should be as good as possible

Complications are few The most serious are pulmonary tuberculosis, pneumonia, iritis, and cardiac complications Teschendorff (1933) reported the occurrence of iritis There was one case in the present series A few cases of pericarditis and endocarditis have been reported

TREATMENT

As has already been said in the case of rheumatoid arthritis treatment should be conducted on *sanatorium lines* and nursed on open air balconies On the few occasions that such an opportunity has occurred the result has been truly astonishing

It is evident that in a disease where loss of weight may be such a marked feature diet is an important factor More especially dairy products are of first importance, plenty of first-class protein is also necessary Added vitamins are useful but in view of the experimental arthritis mentioned vitamin D should be used sparingly

Deep X ray treatment has to some extent revolutionised the treatment of the disease A *first class therapist must always be consulted*

Two methods are in use, the "wide field" therapy and conventional deep X ray therapy

Scott used the former, a special wide angle tube was employed The tube must be not more than 20 or less than 17 inches from the patient and the technique is KV 130 MA 4, filter 3 m m A L and 60-100 γ units Two overlapping twelve-inch fields are used Treatment is usually given once or twice a week, and a pause is made after six treatments The opinion is usually expressed that such a wide exposure leads to toxic symptoms However this may be,

there is no doubt that, in the early days, Gilbert Scott produced good results with his method of treatment. It probably takes longer to produce this effect than in the case of conventional deep X-ray therapy.

Deep X-ray therapy has been used extensively in London both by Professor Windeyer at the Middlesex Hospital and by Dr. Gwen Hilton at University College. They both vary their technique to suit individual patients and lesions. The technique is described in the appropriate publications.

Personal Results

During the last four years, 26 patients have been treated by this method The effect on symptoms is as follows: 14 cases have been rendered symptom-free, 8 have been improved (a great deal as far as pain is concerned), 3 have been unimproved, and one has been made worse. This seems to show that *deep roentgen therapy* is the *method of choice* at the present time. Perhaps one of its *most remarkable and valuable features* is that it seems to make little difference at what stage the case is presented for treatment. Personal cases have done as well at the stage of sacro-iliac ankylosis and spinal involvement as at the early stages. In spite of this the case should naturally be sent for treatment as early as possible.

If X-ray treatment has been tried and failed, or if it has only produced improvement, further measures will be required, but *breathing exercises* may be used at any time. Considerable progress has been made during the war in the development of these exercises, and it is quite clear that they are of the greatest possible use either in increasing the vital capacity, or if ankylosis of the costovertebral joints is inevitable of ensuring that it occurs in the best possible position *No physiotherapy must be given whilst X-ray treatment is in progress.*

Gold has been of use in some cases. Considerably larger doses may be used than in rheumatoid arthritis, doses more in conformity with those used in pulmonary tuberculosis. The standard dose is 50 milligrams a week, but 100 milligrams a week is often given, the whole course, however, goes up to the usual 1 grm. and a pause occurs before the next course is started Reactions are uncommon, but dermatitis occurs occasionally.

Injections of tuberculin, which at one time seemed of use, are quite given up nowadays

The *plaster bed* undoubtedly has an important place in treatment. It must be made with the greatest care, and serially adjusted as deformity is reduced An *orthopædist should be consulted.*

Physiotherapy

The *Kromayer lamp* has a large, and sometimes it seems decisive, place in treatment. As its action is largely local, the X-rays must be carefully studied before its exact application is decided. As a rule the bare face of the burner is used (see chapter on Physical Therapy)

and is passed up and down the paravertebral region in the part most affected If, however, the sacro-iliac joints *and* some part of the spine is affected, the technique is to pass the burner up and down over the sacro-iliac joints first and then to treat the spine afterwards The *erythema time* of the lamp must be ascertained first, in order that a blister dose may be avoided The treatment should be given weekly, and combined with *active and passive exercises*. These exercises should first be given either on Guthrie slings (see Physical Therapy) or, if facilities are available, in the deep pool Whilst in the pool, an underwater douche may well be applied to the part of the spine most affected *Active exercises* should form a part of each treatment, even from the very commencement

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In some cases, especially those with a depressed, introverted personality, the general carbon-arc lamp seems to do good

Ankylosing spondylitis in its final depressing deformed stages is seldom seen nowadays for recognition and treatment of the disease has advanced far, but it is sometimes seen even to-day, when the limb joints have become involved at an early stage It seems likely that the occurrence of this devastating complication has been reduced by modern methods

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CHAPTER XXVII

MEDICAL DISEASES OF BONE

CALCIUM METABOLISM

THE metabolism of calcium is closely linked with that of phosphorus, so that changes in one are often secondary to changes in the other. A reciprocal relationship exists between the level of calcium and phosphorus in the blood.

The digestive processes convert all the calcium in food to its inorganic salts but calcium is nevertheless absorbed with difficulty, and an excess of it in the diet is to be desired. The daily requirement for adults is between 0·4 and 1·0 grammes, and in children and *pregnant or nursing women it is higher.* Absorption is assisted by vitamin D and hindered by excess of certain mineral constituents. Excretion of the element is primarily by way of the large intestine, so that fæces contain the unabsorbable residue plus that which is excreted. Elimination also takes place through the kidneys, and increases with acid-forming diets.

In blood, calcium is found to be absent from the corpuscles, while in the plasma there is more than in the serum. Many of the methods of estimation are open to criticism, but the best give normal limits of 9–10 mgm., expressed per 100 c.c. of serum. Phosphorus is equally distributed in blood constituents, and is usually expressed as milligrammes per 100 c.c. of plasma, normal limits being 2·5–3·5 mgm per 100 c.c. in adults, and up to 5 mgm. in children. The serum calcium figure tends to be low in pregnancy, and high in a child while it is suckling. Phosphatases appear to be needed wherever in the body active calcium metabolism is taking place. They are present in the intestinal mucosæ, in kidney, and in parts of bone, particularly in children. Plasma also contains phosphatase, which can be measured in terms of the number of milligrammes of *phosphorus* which 1 c.c. of plasma will liberate from sodium α-glycerophosphate in 48 hours at 38° C. and at pH 7·6. The normal value is 0.15 mgm., and this may rise considerably in certain bone diseases.

serum calcium levels must at all times be maintained to ensure coagulability of shed blood, and normal irritability of muscle and nerve, though it is surprising that *levels as low as 6 mg.* or as high as 19.8 mg. have been observed in conditions of disease, without symptoms.

Calcium metabolism is affected by various dietary deficiencies. Vitamin C plays an important part in the ossification of bone; without it there is no activity of the osteoblasts, but in spite of this, calcium metabolism remains normal and indeed the zone of provisional

calcification is thicker and less regular than usual. Clinically, the result of vitamin C deficiency is infantile scurvy. After the work of Mellanby on antirachitic propensities of oils and fats, it was discovered that ultra-violet radiation had a similar effect, and finally pure calciferol was isolated Thus vitamin D and calcium and phosphorus metabolism were linked together. Without vitamin D inorganic phosphorus salts cannot be properly absorbed from the intestinal mucosæ, nor be deposited in the osteoid seams of bone

adults, causes a secondary calcium deficiency leading to low serum calcium and tetany

During fasting, calcium is continuously excreted from the skeleton In animals on a diet poor in calcium the trabeculæ of spongy bone become diminished Calcium deficiency in the diet is at least one factor in producing osteomalacia It commonly starts in a period of lactation
countries
may proc
the diet, and the result is hunger osteopathy, clinically similar to osteomalacia

Phosphorus deficiencies are not seen in human medicine, though in cattle of South Africa there is an osteomalacia-like disease called styfsiekte, or "stiff sickness" Experiments have shown that this is due to phosphorus deficiency

Phosphorus and calcium metabolism are specifically affected by the parathyroids Removal of these glands in men and animals results in a low serum calcium level, while injection of a glandular extract such as parathormone raises the level above normal But these effects of parathormone on calcium levels are probably secondary to changes in phosphorus metabolism The hormone *rapidly increases* the excretion of phosphorus and its level in the blood falls owing to the reciprocal balance between blood phosphorus and calcium the level in the serum of the latter rises, and to allow of this the bones yield up calcium Finally the raised serum calcium level causes excess calcium to be excreted into the urine and a drain of calcium is established from skeleton to urine On administering parathormone, the increase in calcium excretion lags behind that of phosphorus, and when the administration is stopped phosphorus excretion returns abruptly to normal to be followed later by the calcium excretion Such alterations in excretion affect the urinary far more than the fæcal output This chain of events suggests where the pathogenesis of generalised osteitis fibrosa lies, for in this disease the increased secretion of hormone from a parathyroid tumour produces the very same effects It must be noted that normal individuals respond in a variable way to parathormone, and injections of this substance may *significantly raise the urinary calcium excretion without necessarily causing a hypercalcæmia*

In hyperthyroidism and also in normal persons given thyroid

extract, or thyroxine, calcium excretion is increased out of proportion to any rise in the basal rate of metabolism. *This action is greater* than that of parathormone, and yet the serum calcium is unchanged Moreover, in hyperthyroidism there is a distinct increase in fæcal as well as in urinary calcium excretion. Thyroxine probably does not directly stimulate the parathyroids, otherwise the serum calcium would rise, nor can a general increase in metabolic activity adequately explain the facts, because there is no increased output of calcium in *fevers or leukæmias where metabolism is increased without thyroid* disease. So thyroxine may perhaps directly increase bone katabolism. It has been found that somewhat less than 50 per cent of cases of hyperthyroidism have demonstrable osteoporosis as a result of increased calcium loss (Hunter, 1930) In myxœdema, conversely, the rate of excretion of calcium is subnormal, and can be restored when thyroid is administered

In studying calcium metabolism it is necessary to know not only the blood levels of calcium and phosphorus, but also the calcium and phosphorus balance, for the direction in which a river flows is not to *be found simply from its level*

A calcium balance estimation can only be made accurately with the patient in a ward under the care of a painstaking Sister-Dietitian Because salt excretion levels become constant only slowly, it is best not to change the conditions of study more than once in twelve days A diet low in calcium is needed to reduce to a minimum the unabsorbed calcium in the fæces The daily intake is fixed at 100 mg, by allowing the patient to choose a palatable dietary from a list of foods low in calcium content This diet must then be adhered to throughout. Fluid and sodium chloride intake is also kept constant, *and distilled water is used in the preparation of* all the food and drink Liquid paraffin may be needed as a laxative, and the urine is kept neutral to phenol-sulphone-phthalein pH 7·3 with sufficient sodium bicarbonate by mouth The fæces are divided into three-day periods by oral administration of 0·3 grammes of carmine alum lake taken every third day This marker should appear in the stools within 24 hours on each occasion The total fæces passed in the period are collected for calcium estimation, *and so is the corresponding* urine sample, in 24-hour specimens over the same three-day period. After a preliminary three-day trial on the prescribed diet, excretion is [illegible] periods of three days each The [illegible] mgm of calcium

GENERALISED OSTEITIS FIBROSA (HYPERPARATHYROIDISM)

Generalised osteitis fibrosa is otherwise known as hyperparathyroidism or osteitis fibrosa of von Recklinghausen. It is due to excessive secretion of parathyroid hormone either from hyperplasia or neoplasm of these glands. Its features are hypercalcæmia, negative calcium balance and decalcification of the skeleton (Hunter, 1930)

The parathyroid glands are variable in site and number. There are usually two on each side, lying *between the pretracheal* fascia and

the posterior aspect of each lateral lobe of the thyroid. Aberrant tissue may be found in any part of the branchial field The superior

when they are placed behind the pretracheal fascia the latter has to be divided to expose them, and they may migrate close to the œsophagus and down into the thorax (Walton, 1931)

The bony changes are generalised throughout the skeleton The cortex and spongiosa are too thin and are replaced by tough, grey fibrous tissue, so that they cut with a knife like rotten wood Deformities and spontaneous fractures are seen. Multiple, grey, spongy

r cysts may be

predominant,

loes not cease

There is fibrosis of the marrow, and there may be osteoclastomata and cysts The parathyroids may show a single tumour, rarely tumours of two glands, and sometimes generalised hyperplasia of all four Bilateral renal calculi of calcium phosphate are commonly found Advanced cases have shown metastatic calcification in lungs, stomach, kidneys and myocardium (Hunter and Turnbull, 1931)

The disease is more common in women than in men Besides symptoms related to the skeleton there are also muscular hypotonia and weakness, anorexia, nausea, vomiting and abdominal cramps, and in advanced cases, wasting. Urinary symptoms include as a rule polyuria, polydipsia and nocturnal frequency, sometimes also renal colic and hæmaturia The former symptoms result from the large quantity of water needed to excrete the excess calcium salts in the blood Where there is metastatic calcification in the kidneys the picture of chronic nephritis with renal failure and phosphorus retention may occur

Occasionally the presenting features are entirely renal However, the classical type is one with a fibrocystic skeleton, and here the skeletal symptoms predominate There are pains in the bones, particularly in the back, pelvis and legs, deformities which slowly progress, and spontaneous fractures Pelvis, spine and thoracic cage are grossly deformed, showing kyphosis, loss of total height from narrowing of the vertebral bodies, distorted ribs, and a deep antero-posterior diameter of the chest The limbs are curved and deformed, making walking eventually impossible The teeth may be displaced or lost but are otherwise normal The terminal phalanges may characteristically become shorter and broader than normal From the point of view of diagnosis, such gross skeletal signs ought to be considered as very late Anorexia and abdominal symptoms may reduce the patient to a state of cachexia.

Biochemical investigations show a raised serum calcium and figures vary between 12 6 and 23 6 mgm per 100 c c Values of 14 mgm per 100 c c are common Plasma phosphorus figures on the other

hand are low, varying between 1·0 and 2·7 mgm. per 100 c c Such figures are diagnostic, except that the plasma phosphorus may be higher where there is renal impairment In these cases where bone disease is demonstrable, the plasma phosphatase is raised. There is a negative calcium balance with a urinary excretion of up to eight times the normal, the fæcal excretion is not raised unless there is renal impairment *Radiographs* show extreme osteoporosis To demonstrate this it is necessary to take a control film, the corresponding bones of the patient and the control being exposed side by side on the same film A control should be chosen of the same sex, age, height, weight and build as the patient, and the same control ought to be employed in all subsequent radiographs. The cortex of the bones is reduced to a thin uneven linear shadow, and the spongiosa loses density The skull shows uniform miliary mottling, and small cyst-like areas The vertebræ are biconcave and reduced in height Deformities of the pelvis in particular and of other bones are to be seen, also spontaneous fractures. The urinary tract should be radiographed for calculi and metastatic calcification If the parathyroid tumour is retrosternal it may throw a shadow in a chest film

Where diagnosis is very difficult, a biopsy and histological section of bone from the tibia may be made.

A number of similar conditions must be distinguished by differential diagnosis. Osteomalacia, thyrotoxic osteoporosis, osteitis deformans and focal osteitis fibrosa are described later. Senile osteoporosis and osteoporosis of disuse, osteoporosis in pituitary basophilism (Cushing, 1932), osteomalacia with renal glycosuria, secondary carcinomatosis of the skeleton, multiple myeloma, renal rickets, osteogenesis imperfecta, chondromata and lipoid granulomatoses are all sometimes confused with hyperparathyroidism In only one of these conditions is the serum calcium ever raised. Cases of multiple myeloma may show serum calcium figures of 13·4 to 16·1 mgm per 100 c c. with a raised plasma phosphorus where renal function is impaired The condition is mainly distinguished on radiological evidence, where the inner aspect of the ivory corticalis is especially picked out with clean-cut areas of complete translucence There is Bence Jones proteinuria in 65 per cent. of cases Osteomalacia with renal glycosuria may closely resemble hyperparathyroidism both clinically and in radiographs The glycosuria is often transient, and slight albuminuria is present. In typical cases the blood chemistry of the two diseases is different, the serum calcium figure being normal in osteomalacia with renal glycosuria. In both diseases the calcium output in the urine is increased. In both the plasma phosphorus figure is low, except where the renal insufficiency of metastatic calcification of the kidneys in hyperparathyroidism interferes with the excretion of inorganic phosphate Such cases are unusual, but may lead to further confusion because of albuminuria and a drop of the serum calcium value even to normal In osteomalacia and renal rickets low serum calcium levels are seen, but the other conditions described all show a normal blood chemistry.

Unless operated upon, the patient becomes bedridden from

weakness and his deformities, and dies within a few years. Immediate postoperative mortality is less than 4 per cent. of the recorded cases, although in 10 per cent. tetany or renal complications killed the patient between 19 days and 14 months after operation.

Surgery is always indicated, for, though a high-calcium and high-phosphorus diet alone will improve skeletal calcification, it is contra-indicated as it increases the danger of renal calculi. Such a diet with vitamin D may be given a few weeks prior to operation. The chief difficulty lies in finding the tumour. In one case (Walton, 1931) a preliminary exploration failed to show the two tumours which were later found lying respectively retrosternally and behind the œsophagus. Sir James Walton therefore advises wide exposure through a collar incision. The sternomastoids are retracted and pretracheal muscles divided. The lateral lobes of the thyroid are rolled inwards to expose the normal sites of the parathyroids. If no

œsophagus is facilitated by this incision. It is important not to mistake a small thyroid adenoma for a parathyroid tumour. After removal the wound is closed in layers, with a small tube drain inserted in the cavity which remains. A high-calcium diet with calcium lactate (5 grammes thrice daily) is given with vitamin D and ultra-violet irradiation. Watch must be kept for the onset of tetany and this controlled if necessary with intramuscular calcium gluconate (10 c.c. of 10 per cent. solution) or even parathormone and intravenous calcium chloride (10 c.c. of 5 per cent. solution) in the worst cases.

The improvement should be dramatic. Bone pain is immediately relieved, spontaneous fractures heal quickly, and osteoclastomata often dwindle. Urinary and gastro-intestinal symptoms cease at once. The density of bones increases and the blood chemistry returns to normal or may swing over to hypocalcæmia, showing a latent or manifest tetany.

FOCAL OSTEITIS FIBROSA

This condition is variously known as benign giant-celled tumour, osteoclastoma, osteogenetic myeloma and myeloid sarcoma. It is a focal or multifocal disease of bone of unknown ætiology and unassociated with any endocrine disturbance. It occurs chiefly in adolescence and is much more common than generalised osteitis fibrosa. Localised grey or brown tumours expand the corticalis and may form cysts. Histologically they are of osteogenic fibrous tissue containing giant cells (osteoclasts). Apart from the local lesions, the bone is everywhere normal. Clinically, the process is slow and often becomes arrested. It may be symptomless until a spontaneous fracture occurs. Deformities are seen in the multifocal variety.

The serum calcium, plasma phosphorus and the calcium balance are normal, and generalised osteitis fibrosa can thus be distinguished

at once. Radiographs show that the whole skeleton is properly calcified except at the sites of the lesions, usually in the ends of the long bones, where there is a fusiform swelling caused by a translucent cyst-like structure, traversed by a few trabeculæ *The cortex is thin and expanded*

Treatment is for the fractures, which unite well. Exploration of the neck for a parathyroid tumour is quite unjustified.

OSTEITIS DEFORMANS (PAGET'S DISEASE)

nic disease
It is not
disease is
unknown. It is not due to an endocrine disturbance, and bears no relationship to generalised osteitis fibrosa It is not inflammatory in origin but may be due to a disturbance of mineral metabolism. The disease commonly starts at 55 and is rare before the age of 40 Its incidence is somewhat higher in men than in women, and sometimes it is familial.

In a minority of cases one bone alone, such as the tibia or the pubis, may be involved. Usually many bones are affected together, in the following order of frequency. pelvis, lumbar spine, femur, tibia, skull, clavicle, humerus, radius and rib. The bones are irregularly thickened and enlarged, and are often bowed. The skull becomes very thick and its foramina are narrowed. The corticalis is broad but has lost its uniform ivory appearance, being coarse, spongy, and covered *with red streaks and dots. Histologically there is* evidence of increased resorption and even more of compensatory apposition of new bone. The transition between diseased and normal parts of a bone is abrupt.

Normal values for serum calcium and plasma phosphorus are constantly found, but that for plasma phosphatase is always above normal. The urinary calcium excretion is increased up to fourfold in 80 per cent. of cases, but is unrelated to the clinical or radiological severity of the case.

stature, or the need *for larger sizes in hats. In 80 per cent. of cases* there is pain, of any type or intensity, related specifically to the bones and usually situated in the back or legs. Headache is common. An obvious increase in circumference of the vault of the skull compared with a normal facial skeleton in late middle life gives *an appearance* which is altogether typical. Bowing of the lower limbs is common

It usually occu

of each bone.

particularly in

upon soft tissues may cause compression paraplegia or cranial nerve palsies. Otosclerotic deafness is common. Spontaneous fracture is rare, but when it occurs union is rapid. Osteogenic sarcoma complica-

ting the later stages occurs, but is also rare Arterial degeneration is to be seen in most cases, with corresponding retinal hæmorrhages

which accounts

h is laid down

appears in one of two forms the spongy and the amorphous, though both may be seen in a single patient, particularly when the pelvis is involved The spongy form is the more common, and consists of irregular coarse striæ both in the medullary cavity and in the corticalis, while the diameter of the bone is increased It may have the appearance throughout of cancellous tissue highly magnified In the amorphous type the bone appears replaced by chalky amorphous shadows and the diameter again is increased In both forms, widening and bowing of the bones are important points in the radiological diagnosis In the pelvis, cyst-like areas are common In the skull the changes are irregular and affect mainly the outer table The calvaria may be several times normal thickness, and the sutures may be obliterated In 40 per cent of cases radiographs show calcified arteries

There is no significant change in the *blood chemistry* other than the raised plasma phosphatase which is common to several skeletal diseases The calcium balance may show an increase in urinary excretion

There need seldom be any confusion on clinical grounds between osteitis deformans and generalised osteitis fibrosa, differential diagnosis of this condition is more fully discussed above Pulmonary osteoarthropathy is distinguished by clubbed fingers Osteoplastic secondary carcinomatosis may cause confusion in the radiographs, but in this disease there is no enlargement or bowing of bones Syphilitic osteitis and periostitis, in spite of its present rarity, must sometimes be considered

The average rate of progress in any bone is shown by radiographs to be 0 5 cm in a year The disease itself seldom shortens the life of the patient, who usually dies of broncho pneumonia or from the effects of arterial degeneration

The course of the disease is not affected by any known treatment Ultra-violet light therapy does not increase the calcification of the

potassium iodide has been given since the time of Paget himself It is used as Lugol's solution, three minims thrice daily, increasing to thirty minims, and given in milk Otherwise, recourse may be had to simple analgesics like aspirin or allonal

Surgical intervention is rarely needed Exploration of the neck for a parathyroid tumour is never justified Rarely, osteotomies may be necessary, or a spinal jacket for painful kyphosis Secondary osteoarthritis of the hip may require appropriate orthopædic measures

LEONTIASIS OSSEA

The term leontiasis ossea is now used in two senses, descriptively when diseases such as osteitis deformans or osteitis fibrosa involve the bones of the skull, and specifically for a progressive sclerosing hyperostosis of the skull of unknown cause The condition was once considered to be infective in origin since it may arise close to the nasal sinuses

Although the disease does not produce a leonine expression, the connective tissue hypertrophy of fibroma molluscum does so, and Virchow considered the two conditions analogous when he advocated the name The disease starts in the nasal fossæ and sinuses, and less commonly at the base of the skull There is slow growth of dense ivory bone under the periosteum and this ultimately breaks the boundaries of the suture lines, spreading in many directions across the skull The blood chemistry is always normal The disease occurs in early adult life in either sex, and may cause obstruction of the nose and lachrymal ducts and ultimately gross disfigurement of the whole facial skeleton The orbit may be encroached upon, the eye protrude and optic atrophy result There is sometimes loss of the sense of smell and of mobility of the jaws Except in the later stages pain is unusual. Beyond palliative removal of the grosser hyperostoses, no treatment has any permanent effect

OSTEOPETROSIS (MARBLE-BONE DISEASE OF ALBERS-SCHÖNBERG)

The terms osteopetrosis, osteosclerosis fragilis generalisata, and marble-bone disease of Albers-Schönberg are all synonyms The disease is very rare It appears to be congenital and may be familial The majority of cases occur before the age of ten years. In one case changes were found in the bones of a fœtus whose mother showed well-developed osteopetrosis (Pirie, 1930)

The condition presents with general backwardness, anæmia and lack of appetite The patient has a broad face with the eyes set wide apart and the root of the nose sunken (Karshner, 1926). Optic atrophy, perhaps due to narrowing of the optic foramen, may occur, and severe dental caries is often present. Spontaneous fractures following slight injury often occur, and there may be coxa vara, scoliosis and deformities of the thoracic cage. The liver is enlarged and the spleen may reach the iliac crest. The lymph glands are sometimes palpable. The blood picture may be normal A few instances of hypochromic anæmia are recorded, but in the majority of cases the picture is that of leuco-erythroblastic anæmia (Vaughan, 1934) The serum calcium and plasma phosphorus figures are normal

At present the diagnosis of osteopetrosis is made by *radiography*. The outstanding feature is a homogeneous density of the bones, and this appears to be due, not to the spread of the cortex at the expense of cancellous bone, but to the laying down of some dense material in the medullary cavity. However, this material is relatively soft, and a bone which looks as if it should be ivory-hard feels like chalk and is brittle (Pirie, 1930)

The condition starts at the ends of the diaphyses and travels towards the mid-point of the shaft. In its early stages it appears as a dense band, later the ends of the bones affected by the process widen and become club-shaped, while the density appears farther up the shaft All bone texture is lost in the affected regions All bones are not necessarily involved, and the process does not affect the whole shaft until the age of puberty In the skull the density is marked at the base, so that all air spaces and foramina tend to be obliterated

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all cases In differential
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absence of periostitis and
mans
arise

OSTEOSCLEROSIS (LEUCO-ERYTHROBLASTIC ANÆMIA)

It is of course recognised that secondary carcinomatosis and multiple myeloma may be associated with leuco-erythroblastic anæmia, but occasionally this anæmia occurs in a benign form apart from either of these diseases It is then very chronic and shows progressive enlargement of the spleen and osteosclerosis which is symptomless

As to the *blood changes* the terms osteosclerotic and myelophthisic anæmia are sometimes used, but the name given by Turnbull, leuco-erythroblastic anæmia, is the most satisfactory (Vaughan, 1934) It may be defined as an anæmia characterised by the presence in the peripheral blood of unusually immature red cells and a few immature white cells of the myeloid series The anæmia is not necessarily severe, nor is there usually a marked leucocytosis The ætiology is unknown Clearly the anæmia cannot be ascribed to destruction or crowding of hæmopoietic marrow by abnormal tissues or cells

In *radiographs* the medullary cavity shows an increased density, while the cortex still remains recognisable The increase of density may be very slight, and controlled radiographs must be taken There is no tendency to fracture If the pathological process is one of fibrosis of the medulla without ossification no change will be recognisable There are of course cases of benign leuco erythroblastic anæmia which show no increased density of bone in radiographs

OSTEOMALACIA

This is a generalised skeletal disease due to deficiency of vitamin D, occurring either as a primary dietary deficiency or, when seen in idiopathic steatorrhœa, as a conditioned dietary deficiency from poor

Central Europe It is seen mostly in women in the reproductive

years often recurring more seriously with each successive pregnancy At one time it was falsely attributed to a hyperactivity of the ovaries, but *it is now certain that it* is a deficiency disease resulting usually from a combination of adverse economic factors. The Oriental woman tends to be screened from the sun, to have restricted movement because of foot-binding, and to live on a diet very deficient in calcium and fats. Lactation is prolonged and repeated and of course represents a drain on body calcium.

Pathologically, osteomalacia is adult rickets (Pommer, 1885) The bones throughout are soft, they bend, and can be cut with a knife like rotten wood Spontaneous fracture is common. The essential abnormality is that calcification of osteoid tissue is deficient, whereas normal physiological resorption does not diminish, so that the whole skeleton is softened.

Pain in the back and thighs is a predominant symptom, especially in winter Extreme deformities of the pelvis, thorax, or long bones develop in a haphazard way, and severe kypho-scoliosis may cause the *head to sink forward on to the chest. The long bones tend to bend* even more easily than they break. A waddling gait develops, which is made more apparent by general muscular weakness Tetany is comm

often

Bı

normal, values of 5·0 to 7 4 mg per 100 c.c. being found Plasma phosphorus lies between 1·8 and 3 8 mgm. per 100 c c The calcium balance is usually negative and can be made positive by giving the patient cod-liver oil. Radiographs show a variable degree of osteo-

kinds. The vertebræ are biconcave and the skull may show uneven but clear-cut areas of translucence. In cases suspected of idiopathic steatorrhœa, estimation of fat in the stools may show total fats up to 40 per cent or more, and the bulk of this is unsplit fat.

Full doses of vitamin D should be given either as cod-liver oil 2 to 4 oz daily or as calciferol 0 25 to 0 5 mg. daily. In addition calcium lactate should be given by mouth, up to 10 grammes daily. Ultra-violet irradiation and a correct

has resulted from ovariectomy,

Fallopian tubes should serve

demands it, Cæsarean section is necessary.

RICKETS

Rickets ... -nfancy which affects principally ... a lack of vitamin D (Mellanby, ... rom the deficiency in the diet of ... , which contain the *natural vitamin, and from insufficient* ultra-violet irradiation of the skin. It is seen, therefore, particularly in poor families in temperate

zones It commonly follows upon prematurity, but is less likely to attack breast-fed than artificially fed infants

The essential *pathological abnormality* is deficient calcification of osteoid tissue, and since endochondral ossification is still going on in infancy, the zone of provisional calcification of endochondral ossification thro[illegible]

[illegible] ...ened, and the ends of the long bones [illegible] and cup-shaped because the region of the epiphyseal line is wider from side to side than normal In cross-section this region shows a broad irregular band of osteoid tissue Bones subjected to particular stresses such as the ribs and long bones of the legs become bent In the skull there is poor ossification of the bones of the vault with thinning and delayed closure of the fontanelle There are frontal and parietal bosses

The majority of cases of rickets have a normal serum calcium, but a low plasma phosphorus In healthy infants the figure for phosphorus should lie between 4 and 5 mgm per 100 c c, but in rickets it may fall as low as 2 mgm per 100 c c A few cases are seen where the phosphorus level is normal but the serum calcium is subnormal, and these children may have symptoms and signs of hypocalcæmia A very few cases are seen with normal blood chemistry

The onset of the disease is gradual and seldom obvious before the fourth month of life The infant is plump and develops restlessness, irritability and sweating of the head There is a general hypotonia of the muscles, laxity of the ligaments, digestive disturbances and a mild hypochromic anæmia The spleen is sometimes palpable and the child grows pot-bellied The rarer cases where the serum calcium is low may show spasmophilia This is a triad of signs comprising tetany (with characteristic signs of Chvostek and Trousseau), convulsions and laryngismus stridulus, which is a crowing inspiration following spasmodic closure of the glottis

Skeletal deformities predominate The epiphyses show bossing and the enlarged costochondral junctions form the rickety rosary The enlargement is most obvious at the lower end of the radius The chest is deformed, the pelvis is flattened and the long bones tend to bend The skull is box-shaped and bossed and has a wide fontanelle Dentition is delayed

X-rays show a slight but generalised osteoporosis The character-stic changes are seen at the ends of long bones, and a radiograph of he wrists is the most useful for diagnostic purposes The epiphyseal ne is hazy, irregular, and concave like a saucer or wineglass The creased width of the epiphyseal line gives the bone an appearance being splayed out When healing occurs it is readily detected in diographs

In *differential diagnosis*, rickets has to be distinguished from liac rickets and renal rickets Cœliac rickets occurs in certain cases cœliac disease It is a conditioned dietary deficiency of vitamin D, cium and phosphorus salts, arising because the fatty diarrhœa has

made absorption of these substances difficult. *Renal rickets* occurs in some cases of renal infantilism, and is not due to a deficiency of vitamin D, but to a disturbance of endogenous calcium and phosphorus metabolism which follows on phosphorus retention, the result of renal insufficiency. In cœliac rickets the serum calcium is constantly low, and tetany is therefore common, but the plasma phosphorus figures are only occasionally lower than normal. In renal rickets there is a raised plasma phosphorus and the serum calcium tends to fall reciprocally, so that again tetany is common.

Rickets is seldom fatal except where secondary complications, such as broncho-pneumonia, are encountered. Skeletal deformities seldom persist into adult life unless the condition is initially very severe or treatment is delayed beyond the third year.

Prevention is essential. During pregnancy the mother must have an adequate diet and enough sunlight. Thereafter, breast-feeding is sound prophylaxis. Between the ages of two months and two years cod-liver oil, up to a teaspoonful twice daily, must be added to the infant's diet. In the established case cod-liver oil is also given, as 50 per cent. emulsion, a teaspoonful thrice daily. Alternatively, a concentrate of pure irradiated ergosterol, such as liquor calciferolis B.P. 5 to 10 minims three times a day, can be used. Heliotherapy or artificial ultra-violet irradiation is valuable. To keep the child off his legs and to prevent further deformity long lateral splints should be applied. Orthopædic treatment will be needed later in life if the deformities persist.

CRETINISM

Cretinism is a condition of hypothyroidism starting in fœtal life. It may occur in endemic form wherever iodine-deficiency goitre is found; rarely it may appear sporadically. A goitre is often found in the endemic form of cretinism. The child is retarded in both physical and mental development. It is apathetic and dull, or even completely imbecile. The total stature is below normal and the face is characteristic, with pale, thick, wrinkled skin, a broad flattened nose and thick lips, from which protrudes a large fissured tongue. The abdomen is protuberant, and often shows an umbilical hernia. The hair is of poor quality, the skin dry, and the dentition delayed. In the skeletal system the fontanelles remain open for years, the centres of ossification appear late and the epiphyses fail to unite.

Radiographs show short thick bones with irregular epiphyses, late to appear, and very slow in fusing. An extra band of density may be seen at the growing ends of the bones; this density will extend throughout the bones unless the illness is adequately treated, in which case it disappears. In the skull the basal bones are short and ossification of the vault is slow.

Untreated cases will remain stunted physically and deficient mentally. Successfully treated children may approach to normal, but the extent of this depends upon how early in life they are discovered to be cretinous. Dry extract of thyroid 1 to 3 grains daily is

required, and must be used indefinitely, the dose is adjusted according to the clinical appearances

MULTIPLE MYELOMA

Multiple myeloma is sometimes called myelomatosis or Kahler's Disease It is a fatal condition characterised by the development of multiple tumours in the skeleton which arise from cells of the bone marrow.

The bones are affected in the following order of frequency spine, ribs sternum, skull, scapula, pelvis, clavicle, humerus and femur The disease is sometimes familial It begins commonly at the age of 55; only 10 per cent of cases occur before 40 The sexes are affected in the proportion of 3 men to 2 women

Multiple deep red or reddish-grey sharply defined tumours are found distributed throughout the red bone marrow They are usually a few millimetres in diameter and very numerous They erode bone, sometimes expand the cortex, and cause deformities and spontaneous fractures The marrow tumours give rise in the urine to Bence Jones protein, which appears as a cloud when the urine is heated to 55° C, redissolves at 85°, but reappears on cooling It is found in 75 per cent of cases, from a trace to a large amount In some cases it appears early in the disease, in others late Its occurrence may be continuous or periodic The serum globulin is usually increased even to as much as 8 per cent (normal 2 per cent) The albumin-globulin ratio drops from the normal 2 2 to a figure as low as 0 5 The serum calcium is usually normal, but occasionally figures from 13 to 16 mg per 100 c c have been found Where renal insufficiency complicates myeloma the plasma phosphorus is found to be high It may rise as the kidney condition becomes worse (Snapper 1943)

The *initial symptom* is pain often bilateral, in the thoracic, abdominal and lumbar regions and sometimes in the neighbourhood of the joints Progressive kyphosis or angular curvature of the spine with loss of total height follows The spine sternum and ribs may be tender on percussion In 60 per cent of cases spontaneous fracture occurs in the ribs, sternum, or later in the long bones There is usually a hypochromic anæmia, which becomes aggravated in the terminal stages In a few instances cells of the type which constitutes the

vertebral form of the disease the growth is confined for some time to the vertebral and extradural tissues Death may occur before the growths become widespread, and sometimes without the Bence Jones protein having appeared in the urine In this variety the patient rapidly develops signs of a transverse spinal lesion with blockage of the spinal canal The thoracic cord is usually the site of compression, and there is focal spinal tenderness

In *radiographs* the marrow tumours are found mainly in the spine, ribs, sternum and skull They are seen as clean-cut elliptical or circular areas of complete translucence, set closely together and varying from 1 mm to 5 cm in diameter The larger tumours may expand the cortex of the bone affected There is a good deal of generalised osteoporosis throughout the affected bones The spine shows collapse of one or more vertebræ. The skull is not thickened Spontaneous fractures, especially in the ribs, are very common.

Biopsy of a portion of bone or examination of a bone-marrow smear from a sternal puncture may reveal the characteristic myeloma cells. These are derived from the hæmatogenous marrow: they resemble plasma cells. Secondary carcinomatosis of bones may cause difficulty in differential diagnosis, especially in cases in which the primary [illegible] iate the disease from [illegible] These two diseases [illegible] affects the skeleton, but the presence of the Bence Jones protein and the blood chemistry are characteristic. In multiple myeloma the serum calcium is usually normal If it is high, it is associated with a high plasma phosphorus, whereas the characteristic effect produced by parathyroid hyperfunction is a high serum calcium with a low plasma phosphorus.

The *prognosis* is hopeless Death often occurs within six months of the onset of the symptoms, but occasionally a patient survives for two years or more. Broncho-pneumonia, cachexia, or compression [illegible]

[illegible] used with good effect It alleviates pain and reduces the size of the tumours, but it does not retard the progress of the disease. It is clearly unjustifiable to explore the neck in search of a parathyroid tumour When the symptoms and signs point to compression of the [illegible] be worth while Laminectomy [illegible] dural mass either pushing the [illegible] noval of the mass decompresses the cord and is followed by improvement. Deep X-irradiation and the wearing of a spinal brace are advised after laminectomy.

GAUCHER'S DISEASE

Gaucher's disease is uncommon. It arises in early life, and is first [illegible] enlargement Hepatic [illegible]

endothelial hyperplasia in which the cells involved are filled with a galactolipin called kerasin. The skin of the face, neck, forearms and hands frequently shows a peculiar brownish-yellow pigmentation The pigment does not appear to be hæmosiderin. Epistaxis and bleeding from the gums are common but never severe. Anæmia is absent except in the very late stages Apart from the inconvenience due to enormous abdominal distension the patient may complain little, and cases are on record of over 40 years' duration.

skull and pelvis may be involved Sometimes scattered through the bones there are focal pale rounded areas which expand the cortex These areas are deposits of kerasin

DONALD HUNTER

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CHAPTER XXVIII

GOUT

GOUT can be defined as a hereditary constitutional disorder of metabolism Its characteristic features include an elevated blood uric acid, the deposition of sodium urate in many tissues but particularly in the joints, and periods of complete health between attacks. The term gout is of ancient origin, having been introduced in the thirteenth century, and is derived from the Latin "*gutta*," meaning

joints "(

agra, or

knee joi

reintroduce the term podagra Gout however is a much better name, as it signifies no special theory of ætiology and no anatomical distribution of the lesions, which indeed may be far-flung. The name should be preserved until the ætiology is understood.

Ætiology

As uric acid and its precursors make up such a large part of the problem of gout, it is necessary to have some knowledge of their metabolism



Fig 204

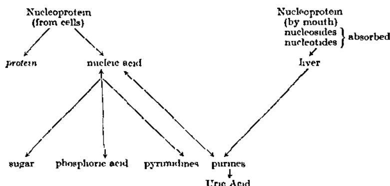
A case of *gout* to show the swelling of the mid phalangeal joints and early muscle wasting

Metabolism of Purines

Nucleoproteins are contained in the nuclei of all tissues of the body By hydrolysis of these compounds nucleic acid is obtained, this can be further split into purines, pyrimidines, sugar and phosphoric acid Of these compounds the purines only are of interest in gout, and it will be seen from the above that they are contained in all tissues of the body

Ingested nucleoproteins are hydrolysed by the gastric enzymes into nucleic acids, which in turn are acted upon by the duodenal and intestinal enzymes which further reduce them to nucleotides and nucleosides in which form they are absorbed

This absorption is not complete, the unabsorbed compounds being decomposed by bacteria The final fate of the absorbed nucleotides and nucleosides is transformation into uric acid Experimental evidence indicates that this transformation occurs in the liver, but extra-hepatic mechanisms also exist



Brief Schematic Outline of Purine Metabolism

Ample experimental evidence exists that the purine ring may be synthesised by the body It is seen that uric acid is formed from two sources, endogenous (from the body nuclei) and exogenous (from the food) The endogenous uric acid production, provided that a diet of adequate caloric value is given, remains remarkably constant for a given individual The exogenous production however varies widely according to fluctuations in the nucleoprotein content of the diet, approximately one-third is endogenous and the remaining two-thirds is exogenous

In most mammals except the ape and the human a further enzyme is present, uricase, which *acts on the uric acid to form* allantoin Uricase has never been demonstrated in man, and the allantoin excretion is so low that it may be accounted for by the traces present in the food The animals that excrete



Fig 205

Gout Showing the "punched-out" areas in the mid phalangeal joint of the ring finger and little finger One or two other joints show early change

allantoin rather than uric acid appear to have the advantage, as allantoin is some 200 times as soluble as uric acid. In birds and reptiles this mechanism would appear to be a *physiological necessity*, as the quantity of uric acid excreted is relatively enormous owing to the fact that most nitrogenous wastes are excreted in this form instead of in the form of urea

There is one class of purines which is an exception to this general rule of purine metabolism The methylated purines (caffeine, theobromine and others) are *only partly changed into uric acid*, the remainder is excreted unchanged or partly demethylated Theobromine is apparently excreted entirely unchanged or partly demethylated

Pathology

It is now generally conceded that the pathological manifestations of gout are due to deposition of sodium urate in the affected tissues with the resultant inflammatory and degenerative change so produced

Inferior histological technique often fails to reveal the causative urate deposit, but with correct technique this can be shown in most cases Staining, by Galantha's method, of tissue fixed in absolute alcohol is a satisfactory procedure The urate deposits in tissues are [illegible] reaction, and this is the [illegible] re is a marked predilec- [illegible] reasons for this are not known

Macroscopic examination of a gouty joint may reveal nothing amiss except urate deposits on the articular cartilage, but if the condition is chronic, considerable disturbance of the joint architecture may have resulted owing to bony destruction and urate deposits; in these cases the extra-articular structures will also show marked change. In very advanced cases a fibrous or even bony ankylosis may be present, though this latter complication is usually seen only in the small joints

The articular cartilage is the frequent and sometimes the sole portion of the joint to be affected, and the central portion of the cartilage is affected more frequently than the periphery

Microscopic examination shows that the urates are embedded in the superficial portion of the cartilage, though occasionally they penetrate the bone, the cartilage *surrounding the deposits* may show marked degenerative changes In the soft tissues urate deposits [illegible] reaction with fibrosis are seen [illegible] varying degrees of [illegible] is usually present [illegible] whether they are a reaction *to the urate deposits or a degeneration* caused by vascular sclerosis. Undoubtedly the kidney lesions are sometimes responsible for a major degree of renal insufficiency.

Hyperuricemia

At the present time the methods employed for the estimation of blood or serum uric acid are extremely unsatisfactory with regard to the absolute values obtained, but are moderately satisfactory with regard to comparative values

The two most satisfactory and most commonly employed methods are those of Folin (1934) and Benedict (1931), which depend upon the reduction of complex tungstate reagents to coloured compounds, neither of these reactions is specific for uric acid, and the presence of other substances in the blood affect the result If however, these methods are employed with due attention to detail they are satis-

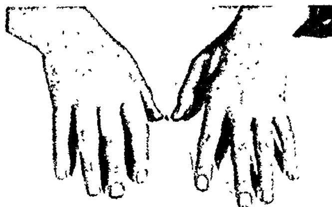


Fig 206

To show the appearance of the hand in acute gout Note that only the right hand is affected Generalised swelling and œdema are present

factory for clinical purposes Specimens collected and centrifuged under oil (to prevent the escape of bicarbonate and shift of uric acid from cells to serum) provide the most accurate serum determinations which are more satisfactory than those on whole blood The most accurate method available was introduced by Blauch and Koch (1939)

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All available evidence indicates that most attacks of gout are accompanied by a high blood uric acid and that in many cases the blood uric acid eventually becomes fixed at a high level

Increase of blood uric acid may arise theoretically in three ways (1) by decreased destruction, (2) by increased formation, (3) by decreased elimination

The question as to whether uricolysis can occur in the human is important, as its answer has considerable bearing on the pathogenesis of gout The evidence available is negative, the pathway for

uricolysis in animals, as has already been mentioned, requires the presence of uricase which leads to the formation of allantoin. Neither uricase nor abnormal amounts of allantoin have ever been found in man. An alternative pathway with the formation of urea has been suggested, but an extensive search has not revealed any enzyme capable of attacking uric acid. Experiments with feeding of uric acid are inconclusive as bacterial decomposition to an unknown extent occurs in the intestine. Injection of lithium urate followed by recovery studies has led to divergent results, some workers being unable to recover the quantity injected, others reporting complete recovery and the rest reporting over 100 per cent. recovery. Thus there is no real evidence that uricolysis is possible in man.

Increased formation according to our present knowledge could result only from increased breakdown of cellular nucleoprotein. No evidence has been adduced to support this suggestion. Additionally, increased formation should be shown by increased excretion as it has been demonstrated in normal persons that a high blood uric acid level is, as would be expected from a knowledge of renal physiology, accompanied by increased excretion. Though most workers report that gout patients kept on a low purine diet excrete less uric acid than do normal controls, instances of increased uric acid excretion have been reported (Talbott and Coombs, 1938). However, in view of the known variability of urate excretion it is likely that these episodes were of a temporary nature following on a period of retention. Prolonged and accurate balance studies are needed.

The theory of decreased excretion is now left for consideration, and this theory is supported by a number of workers in this field.

Renal Function

Modern methods of renal examination, i.e. inulin clearance, diodrast clearance, and determination of the total excretory mass, show that in a substantial number of gout cases a significant degree of depressed renal function is present (Coombs *et al.* (1940)). However, it appears that this renal impairment is only revealed by the more refined tests, and that on the whole this change is seen only in the later stages of the complaint. Many cases of gout ultimately die a renal death, and in them uric acid will accumulate in the blood as do other urinary excretions, the late rise in blood uric acid of these cases may be related to the general renal impairment.

Of greater importance in the pathogenesis of the disease is the renal status of the earlier cases, many of these have apparently normal renal function, and yet their blood uric acid is often considerably raised. It has been suggested that to explain this anomaly specific renal impairment of uric acid excretion must be postulated. A large body of evidence has been adduced to support this hypothesis, unfortunately a good deal of it is singularly unconvincing. The problem has been attacked in two ways, firstly by comparison of the uric-acid concentration ratio $\left\{\frac{\text{urate in urine}}{\text{urate in blood}}\right\}$ in normals and gouty persons, and secondly by means of urate clearance tests.

Initial observations on the concentration ratio in normals and patients suffering from gout failed to reveal significant differences; when however "normal" cases were defined as persons with a high blood uric acid due to some other condition (i e leukæmia), positive results were reported (Brochner-Mortensen, 1939) The matter is one requiring most extensive investigation, as a positive finding cannot be accepted as significant unless the renal status of the subjects is determined by the most exact methods available Owing to the great advance in renal function tests (diodrast, inulin, etc) that has taken place within the last few years, practically all earlier work is suspect



FIG 207

Gouty knees. These joints are in the stage of gouty arthritis, when the joints fail to resolve between attacks

Coombs *et al* (1940) in a model investigation considered that their evidence was insufficient to demonstrate specific excretion failure for urates as, though the figures were in some cases suggestive, the failure of renal excretion of urates appeared to run *pari passu* with the general renal status of the patients This paper, employing a large random selection of gout patients, demonstrated a most striking incidence of renal impairment Data from urate clearance is confusing, great variability not only between different authors, but also patients in the same series, is seen It appears that, unless the methods employed were of considerably less technical efficiency than has been generally thought, the urate clearance test gives no useful information as at present carried out The exhaustive paper of Folin,

urate excretion exists must, on the present evidence, be regarded as unproven

A pertinent point has been raised by some workers who reported a change in the ultrafiltrability of serum uric acid in gouty subjects as compared with normals At the moment the evidence is minimal, but a change in ultrafiltrability of uric acid, if conclusively demonstrated to be present, would be of immense help in the explanation of the high blood-levels found in gout

It must be concluded that the hyperuricemia found in gout has not yet been satisfactorily explained

Physico-chemical Considerations

It is not possible to explain the presence of tophi and other urate deposits on the basis of raised blood uric acid, as (*a*) neither tophi nor gouty arthritis are seen where the blood uric acid is raised in other conditions such as leukæmia, resolving pneumonia, polycythæmia, and terminal renal states, except rarely in cases which are probably complicated gout. Occasionally gout is associated with leukæmia or polycythæmia. This piece of evidence is in no way conclusive, as, compared to gout, these are relatively short-lived complaints; (*b*) the solubility product of sodium biurate is never exceeded under clinical conditions. The solubility of uric acid is dependent to a great extent on the sodium and hydrogen-ion concentrations Under physiological conditions precipitation is not possible below 6 5 mg. per cent (Peters, J. P., and Van Slyke, D D., 1931). In actual fact, uric acid shows little tendency to precipitate out, even of super-saturated solutions. Two other factors also mitigate against precipitation under physiological conditions Benedict, Davis and Newton (1922) showed that a considerable portion of the blood uric acid was held in combined form with a pentose (d-ribose) in the corpuscles This portion will exhibit no physico-chemical influences on the solubility product. Secondly the plasma proteins, probably owing to their colloidal properties, exhibit the most striking effect in increasing the solubility of uric acid Folin *et al.* (1924) showed that in birds ureteric ligation caused the blood uric acid to rise to great heights (300–400 mg per cent) without any evidence of precipitation

Thus it appears essential to postulate some local cause for the deposition of urates in joints, as the tophus is in general a late lesion. The problem of articular and extra-articular deposition of urates is to some extent different, as in the former case the articular cartilage is the site of predilection and deposition from the synovial fluid requires serious consideration The composition of synovial fluid in gout as compared with normals is shown below.

SYNOVIAL FLUID IN GOUTY ARTHRITIS

	Normal			Gout		
	Average	*Low*	*High*	*Average*	*Low*	*High*
Leukocytes, per cu mm	63	13	180	13,800	1,000	31,400
Polymorphonuclears, per cu mm	6 5	0	25	83	48	94
Relative viscosity	150	51	409	4 8	3 6	5 9
Protein, gm. per 100 c c.	1·72	1 31	2 13	4 30	3 10	4 07
Globulin, gm per 100 c c	·05	·		1 39	1 08	1 79
Mucin N, gm per 100 c c	105	068	·135	065	034	098
Sugar	Essentially same as in serum			Essentially same as in serum		
Uric acid	,,	,,	,,	,,	,,	,,

(This table is taken from Duncan's *Diseases of Metabolism* (Bauer and Klemperer))

It is to be noted that the gout fluids were obtained from patients with effusions. The above authors, Bauer and Klemperer, stated that though no urate crystals were seen in these fluids they have seen urate crystals in synovial fluid obtained post-mortem from cases of chronic gouty arthritis.

That the concentration of urate in the synovial fluid (gouty effusions) is approximately equal to the concentrations in the blood was also demonstrated by Folin *et al* (1928). These workers stated that, since their results were obtained in cases with effusion, the synovial membrane must be assumed to show increased permeability, and the results could not be transferred to normal joints.

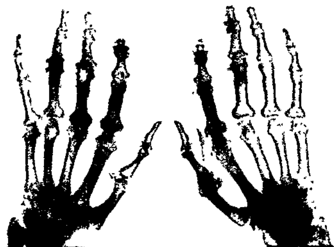


Fig 208

An over-exposed print to show localised area of decalcification in L3 mid phalangeal joint.

However, the work of Ropes, Bennet and Bauer (1939) offers adequate evidence that the composition of synovial fluid is in actual fact that of a dialysate of plasma. There is therefore reasonable evidence to support the view that even in joints without effusion the concentration of uric acid in the synovial fluid is equivalent to that of the blood

Unfortunately our knowledge of the physiology of the synovial fluid is woefully incomplete. We do not know whether changes in this fluid, particularly with regard to the protein, both quantitative and qualitative may not occur, which render it liable to deposit uric acid

Similarly the metabolism of articular cartilage is largely a closed book Its avascular nature, its low general metabolism, and its tendency to "natural" degenerative change (Bennet, Waine and Bauer, 1942) favour the conception that under relatively slight

stimulation an area with suitable local conditions for urate deposition may be produced

It would appear that any theory purporting to explain deposition of urates in joints must also provide for conditions in which the urate deposits may be removed, as the spontaneous disappearance of tophi is not unknown and post-mortem examination of a joint which has been the site of gouty arthritis occasionally reveals no lesion.

Precipitating Factors

From what has been said it is obvious that local factors must play some part in not only determining the onset of the condition but also in determining its site.

Trauma has been repeatedly accused of being the responsible agent, largely on the ground that the first metatarsophalangeal joint is exceptionally liable to trauma, and that a history of local trauma may be sometimes obtained from patients However, many patients give no history of trauma and it is difficult to see how the ear, a frequent site of tophi, becomes traumatised. It is conceivable that the local inflammation incident upon trauma may in some cases provide the requisite conditions for urate depositions



Fig 209

Tophus on the hand in a case of gout. Uric acid crystals were obtained on puncture.

Many other insults such as operations, medication with many substances, infection, indulgence of the appetite and alcohol have been suggested as precipitating causes, but the evidence to incriminate these is not conclusive. It must be admitted that the local and general factors responsible for precipitating the state are at the best mere conjecture.

Diagnosis

Heredity.—A family history of gout is frequently obtainable, and should always be sought, as its presence raises legitimate suspicions of this condition

Various workers have reported a widely differing incidence of positive family history; it is reasonable to expect such a history in 50–60 per cent. of cases examined. In a personal series the figure was 32·5 per cent.

Age and Sex Incidence.—Approximately 95 per cent. of gout occurs in the male, this peculiar incidence is as yet unexplained; certain authors have stated that gout does not occur in castrated males, but this is mere conjecture, as a very large series would be required to test this view.

Gout is very rare in the first or second decades and becomes increasingly frequent from the second to the sixth decade, the peak incidence is probably in the forties and fifties. Gout is regarded by some authorities as a vanishing disease, but this is hotly contested by others, who think that it is often not recognised In the absence of any figures as to the true incidence it is not possible to be dogmatic on this point, but it is possible to say that gout is not uncommon, and that its manifestations may escape correct diagnosis for years.

Regarding the relative incidence of gout, Hench (1940) estimates that 5 per cent of patients consulting the Mayo Clinic for articular complaints suffered from gout, whilst in England the Ministry of Health Report (Glover, 1924) on Rheumatic Diseases showed an incidence of 2 7 per cent gout, more recently Fletcher (1945) reported an incidence of 4 per cent in a survey of 1,000 patients complaining of rheumatism

Classification

Hench (1936) has employed a fairly complex classification of the disease into two stages each with two phases, this is of considerable value in understanding the course of the disease and is reproduced below

	First Stage (3–42 years, average 11 7 years)		Second Stage	
	Stage of Acute Recurrent Arthritis with Complete Symptomatic Remissions (Variations in frequency, duration and severity of subsequent attacks not indicated)		Stage of (Symptomatic) Chronic Arthritis	
Arthritis	▲ ▲ ▲	▲ ▲ ▲ ▲ ▲ ▲ ▲	Residual joint disease	
	Phase 1	Phase 2	Phase 3	Phase 4
	Early attacks of acute recurrent arthritis	Later attacks of acute arthritis but still with complete remissions	Early active chronic arthritis with acute exacerbations	Late, relatively painless, inactive residual arthritis
Hyperuricemia	In attack + or 0 often transient, between attacks 0 or +	Generally but not always + (established)	Almost always + to + +	+ to + +
Tophi	Generally 0, occasionally +	+ or 0, often 0	Generally +, occasionally 0	Almost always +, often ulcerating

(Hench, P S., *J Lab and Clin Med*, October 1936)

Happily gout presents a fairly distinctive clinical picture; this is fortunate, as the diagnosis has sometimes to be made without confirmatory signs such as tophi, a raised uric acid, or X-ray changes.

Clinical Manifestations

The classical onset is usually seen in a healthy male of forty who awakened in the night by a severe pain localised to one joint.

frequently the big toe. The pain may appear at any time during day or night, or attack most joints; the other common sites of onset are the elbows, wrists and knees. A slight fever may accompany the attack.

Within a few hours of onset the affected joint is red, swollen, hot, extremely tender, and exhibits considerable pain with marked limitation of movement. The inflammatory œdema is considerable and often extends well beyond the joint margins. Effusion into the larger joints is not uncommon at this stage. The overlying skin is red and shiny and there may be a lymphangitis with dilatation of the local veins; these features, together with the great swelling, may result in the diagnosis of cellulitis or purulent arthritis. In certain situations, particularly on the dorsal surface of the foot and the very rare nasal cartilage form, the resemblance of this condition to an inflammatory process has been sufficient to deceive the very elect.



FIG. 210

A case of gout showing swelling of the big toe joint, and some œdema of the toes with dilated veins The picture does not show well the *swelling of the foot, which often* accompanies this lesion.

A point of considerable diagnostic significance is seen as the attack subsides, for after passing through a stage of pitting œdema, the overlying skin may itch and desquamate, this is very unusual in the other arthritides

The severity of the initial attack is very variable, as is the duration, most attacks have terminated with complete restoration of function in the affected part within a week or two. Rarely the attack is atypical and either a joint is involved persistently, several joints are involved either at the same time or in sequence, or a migratory polyarticular form is seen, especially in juveniles. These atypical forms may give rise to marked diagnostic difficulty and only prolonged observation with necessary diagnostic tests provide the clue It is to be emphasised that these forms are rare, and that practically all attacks follow the classical type.

A period of complete recovery now lasts for a variable time, but usually within a year or two a similar attack occurs which again clears

up Attacks now occur with increasing frequency, till eventually the joints are left with residual pain, stiffness and deformity—the stage of chronic gouty arthritis has been reached Occasionally ankylosis of the smaller joints makes its appearance in the late stage.

Cases of gout do not all follow this conventional pattern, sometimes after the initial attack no symptoms may be manifest for ten, twenty, or even a longer period of years Sometimes, especially in the younger cases, the course may be fulminating, attacks appearing with great frequency and leading to severe articular damage within a few years

Tophi may appear at any stage, occasionally a tophus may be found prior to the initial attack tophi are present in approximately 5 per cent of cases at the time of the initial attack The size is very variable, these lesions may be minute, and a most careful search should always be made especially in the sites of predilection, the ear, the olecranon and prepatellar bursæ, the tendons of the fingers and wrists, toes, ankles and heels

Albuminuria may appear early or late, but much more frequently late Albuminuria, though sometimes regarded as of grave prognosis,

gout, and should raise suspicion of this condition

Certain diagnostic pointers are sometimes of value Minor trauma, dieting, or alcoholic excess are common provocative phenomena Hench has stressed the frequency of gout following surgical procedures Gout in susceptible subjects is sometimes provoked by transfusions, liver extract, injections of salyrgan, vitamin B, and numerous other medicinal substances

Laboratory Tests

Any tophus or suspected tophus should be needled or excised, and examined for the presence of urates by microscope and the murexide test The demonstration of urates is pathognomonic of gout

The blood or serum uric acid should be estimated This has been considered earlier In the first stages a diagnosis of gout may have to be made in the presence of a normal value X-ray examination is only of limited value, as a patient may have gout for many years without showing X ray changes, and even when a pathological film is obtained the interpretation is not easy The changes in gout show punched-out areas of bone (urate deposition), usually 5 mm or more in diameter, located in the subchondral bone of the base or head of the phalanges in the hands or feet An X-ray of the feet and toes should be performed in suspected cases as changes are usually earliest in these situations The punched-out areas are not pathognomonic as similar appearances (usually less in degree) are seen in degenerative joint diseases, rheumatoid arthritis and many bone diseases Marginal bone hypertrophy is not uncommon, and finally decalcification is occasionally seen These appearances are all non-specific, and must be considered in conjunction with the clinical picture

Blood examination is of little assistance, the blood sedimentation rate is frequently raised during the attack and is often normal between the attacks. Mild or moderate leukocytosis during an attack is common Anæmia is sometimes present in the late stages of the disease but seldom early. The blood urea remains within normal limits till a serious degree of renal impairment is present, but tests of renal function, especially the specific gravity concentration technique, often reveal some degree of impairment.



Fig 211

To show changes in the metatarsophalangeal joint of the big toe in long-standing gout

In view of the frequency of renal impairment or renal stone in this condition, a combination with articular symptoms should suggest gout.

Treatment

The treatment of the acute attack of gouty arthritis with colchicine is very satisfactory, but in the treatment of the chronic condition, and the prevention of relapses, the methods employed are not only relatively unsatisfactory but are of doubtful theoretical validity.

These difficulties in treatment are a reflection of the vagueness of our ætiological concepts. Thus the local conditions that cause urate deposition are largely unknown, the reason for and the exact significance of the hyperuricemia is also uncertain.

The use of colchicine in the control of the acute attack is successful
...he blood urate nor
... properties (other
...s be prescribed in

crystalline form made up in tablets, as other preparations such as the tinctures are not reliable

In the acute attack immediate bed rest is required as weight-bearing prolongs the attack, besides being very painful The affected part should be immobilised and elevated, hot moist dressings usually give comfort, but sometimes cold gives relief where heat has failed Moist heat is much preferable to dry heat A bed cradle for the removal of the weight of the bedclothes is essential



Fig 212
To show changes in the metacarpophalangeal joint of the right index finger

Colchicine tablets (1/120 gr 0 5 mg) are administered every tw
irs until either the pain is relieved or, more frequently, till toxi
iptoms appear It is not usually necessary to administer more
n 8–10 tablets in the first twenty-four hours, as the average
iber of tablets required to control an attack is 10, although
iderable variation occurs in individual patients
Toxic symptoms may be severe nausea, vomiting and diarrhœa,
diarrhœa is treated with paregoric and bismuth given in large
; In the usual case one course of colchicine will be sufficient,
rticular symptoms clearing in 24–72 hours If, however, the
ılar symptoms continue colchicine may be cautiously restarted
aller doses, 1/120 gr three or four times a day During the
; a light diet should be given with a high fluid intake A
l note should be taken of the amount of colchicine required to

produce toxic effects, as in subsequent attacks a tablet or two less *may be given, usually without loss of therapeutic effect,* and with much greater comfort to the patient.

It is possible that urate kidney-stone formation may be inhibited by a large fluid intake and the exhibition of alkalis; sodium citrate *(2 drm daily) is suitable*

Cincophen (atophan) has been employed extensively in the interval treatment of gout. The action of the drug is to initiate a urate diuresis, probably by interference with absorption of urate from *the kidney tubules (Coombs, 1940). This* diuresis is seen both in normal and gouty persons and lasts 2-3 days; the drug also has a marked analgesic action Unfortunately it causes toxic hepatitic necrosis in a very small number of subjects, and no method of administration is completely safe. The usual dosage is 0 5 g. (gr 7½) 3 times daily for 3 days every week, given with a high carbohydrate diet and a high fluid intake with alkalis. Salicylates have a comparable action and in some clinics the use of cincophen has been abandoned *However certain authorities feel that cincophen still* has a real place in the management of gout, not only as a help in preventing relapses, but also as a prophylactic against kidney damage The use of cincophen is not recommended in the therapy of the acute attack

The use of salicylates as interval treatment has also been recommended, they also produce a urate diuresis and analgesia, they are usually administered as sodium salicylate 80 gr on three consecutive days in the week, *this therapy is free from danger.*

Colchicine has been employed during interval treatment by some physicians, the dosage of 1/120 gr three times a day sometimes appears to provide amelioration of chronic or rapidly recurring attacks of gout. *No hypersensitivity develops to the drug and its action* remains unimpaired.

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CHAPTER XXIX

SCIATICA

SCIATICA may be defined as pain felt in the distribution of the sciatic nerve It has been suggested that the term should be reserved for those cases in which there is definite evidence of compression of lumbosacral nerve roots In the majority of cases this evidence is ambiguous, and so unsuitable for use as a criterion It is better to keep the word sciatica in its all-embracing sense, and it will be so used in this section The essential features of sciatica are the distribution of the pain over the buttocks, the back of the thigh, the calf, the lateral aspect of the leg and sometimes of the foot

The *lumbosacral plexus* lies in the pelvis on the pyriform muscle Anteriorly it is covered by the parietal layer of pelvic fascia which separates it from the branches of the internal iliac artery

The *sciatic nerve* arises from the anterior primary divisions of the fourth and fifth lumbar and the first second and third sacral segments Just outside the intervertebral foramina a small recurrent twig, known as the nervus sinuvertebralis turns back into the intervertebral canal and supplies twigs to pedicles, vertebral bodies, perimeningeal tissue and periosteum Although originally described by Purkinje in 1845 the part played, if any, by this small structure has not so far been defined It has again been discussed by Steindler *et al* (1938). It may be significant that the nerve receives a white ramus from the common trunk and a grey ramus from the sympathetic chain just outside the intervertebral foramen It is thought to carry certain sensory paths, and it is within the bounds of possibility that some cases may be of reflex origin through this pathway and fewer due to direct compression in the canal The sciatic nerve passes out of the pelvis just below the level of the pyriform muscle It is composed of a tibial component (L45 S123) which becomes the internal popliteal nerve and a peroneal component (L45 S12) which becomes the external popliteal nerve The division occurs at variable places, usually about half-way down the thigh The sciatic nerve supplies the hamstrings and the muscles below the knee Sensory branches supply the skin on the lateral aspect of the leg and the dorsum and sole of the foot

The Relationship of the Component Roots in the Intervertebral Foramina

These foramina are pear-shaped, with the narrower portion below the foramina decrease and the nerves increase in size in the lumbar region from above downwards, so that the largest nerve comes to lie in the smallest foramen The relationships of the nerves are seen clearly in the accompanying diagram They lie in the narrow superior part of the foramina It will be noticed that the inter-

vertebral disc is a direct anterior relation of the roots, and that the capsule of the apophyseal joints (superior and inferior articular facets) is a direct posterior relation, with the *ligamentum flavum*.

The lumbosacral cord lies a little medially to the sacro-iliac joint

Special Signs in Sciatica

1. *Forward bending* either standing or lying. Note the distance the fingers are from the toes—a very important test. (See under Clinical Examination.)

2 *Lasègue's sign*, or straight-leg-raising test The best way to do this is to flex the hip to a right angle with the knee bent, and then gradually straighten the knee. It needs to be done carefully, and the patient's attention should be drawn away from what is being done Another way is to raise the leg off the couch, flexing the hip with the knee straight. When pain is felt *in the thigh drop the leg an inch* and dorsiflex the foot. This produces pain in sciatica, not in sacro-iliac disorders (Mennell's modification)

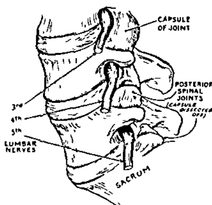


Fig 213

The relationship of the nerve roots in the intervertebral foramina, showing how the narrow portion contains the root itself

3. *The drop test* (O'Connell, 1946) —This is a modification of the Lasègue sign. It is carried out with the patient supine Both legs are raised together to a point just short of producing pain The sound leg is allowed to drop to the couch and if the test is positive an exacerbation of pain is produced. This test is generally positive if the Lasègue sign is present

4. *The femoral nerve-stretch test* —The patient lies prone, the hip is hyperextended and the knee flexed. O'Connell says that this produces pain in disc lesions of the second and third lumbar discs It has been shown that tension is produced in the third and fourth lumbar nerves by this manœuvre. This test is said to be positive in lesions of these when the Lasègue sign is negative

5 *The side-lying drop test.*—The patient lies on the sound side The lower leg is flexed, hip and knee. The pelvis is held down with one hand, and with the other the knee of the uppermost leg is flexed to a right angle The thigh is then fully abducted, and the hip hyperextended. If the iliotibial band is affected the leg will remain in the abducted position. Another way is to drop the abducted leg to the couch If the test is positive the leg will be held up and fall slowly Try the same test on the other side for comparison (Ober, 1935).

Wasting of muscles ...y be genera... ... cases, or particularly

marked either in the glutei or thighs "Trigger points" must be looked for

Reflexes —The knee jerks are intact in sciatica, but often lost in anterior crural neuritis (L3,4,5) The ankle jerk (S1, ?S2) is often lost in sciatica

Strength —All movements in the limb joints should be tested, but the most useful is dorsiflexion of the toes Compare the strength on the two sides

Tenderness of the nerve may be marked over the sacro-sciatic notch, at the head of the fibula, or over the external malleolus It is very difficult to be sure whether this tenderness is in the nerve or in the structures which overlie it The skin itself is sometimes tender

Scoliosis is fairly constant in all but the mildest cases The list may be in either direction or uncommonly may alternate If the concavity is towards the affected side (homolateral) the hip is usually slightly flexed This relaxes the whole trunk of the nerve If on the other hand it is away from the affected side (contralateral) the intervertebral foramina are opened up a little and this should relieve root sciatica Unfortunately the findings are not consistent The tilting of the pelvis often runs *pari passu* with the scoliosis.

The posture is fairly characteristic and it is as well to see the patient standing with no clothes and to check the spinal findings in that way

Parasthesiæ and numbness are complained of in some cases, and perhaps more often in severe than in mild cases True sensory loss is uncommon

Trauma is said by many to be an important feature in sciatica Estimates of its incidence vary enormously, from 80 per cent. to 10 per cent in different series Repeated microtrauma is sometimes assumed in cases where no gross trauma is found

Lumbar kyphosis is an important point and must always be looked for Tenderness over the lumbar spine is stressed by some authors, as is exacerbation of pain by coughing and sneezing This occurs in nearly all cases

The Causes of Sciatic Pain are numerous As in the case of brachial neuralgia they will be dealt with on a regional anatomical basis To simplify the problem, however, known but uncommon causes will be listed first and dealt with briefly Later the common but uncertain causes will be dealt with in the same way, and diagnosis and treatment will be duly elaborated By this method the reader will be warned of the diagnostic dangers, but will not be overwhelmed with a maze of ætiology The section will therefore be divided into cases of sciatica of known but uncommon causation and cases of sciatica of doubtful origin

SCIATICA OF KNOWN BUT RELATIVELY UNCOMMON CAUSATION

In the Cord

Intramedullary Tumours
Tumours of the Cauda Equina

Pachymeningitis *(either Tuberculous or Syphilitic)*
Arachnoiditis (following spinal anæsthesia)
Tabes Dorsalis
Disseminated Sclerosis

The symptoms and signs of cord pressure will be present in the case *of tumour, and with cauda equina* lesions the characteristic signs and symptoms These include severe low-back pain, incontinence of urine and fæces, and absent knee jerks The pain may be very severe and accompanied by perineal anæsthesia and ulceration Occasionally symptoms and signs are few and the diagnosis may be very difficult

In the Cord Space

Herpes Zoster
Sciatic Neuritis

Herpes zoster shows itself by the characteristic rash, and has been mentioned several times in the literature. No personal experience is available

Sciatic neuritis (of non-specific origin) is denied a place by many authorities. Holmes and Sworn (1945) describe three cases operated on for a supposed ruptured disc in which no lesion of this kind was [illegible]

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of the œdematous nerve roots found by Holmes with herpes zoster is very uncertain, but he says that herpes zoster has occurred in the fifth *lumbar root after partial excision of the fourth lumbar disc* The puzzling feature is that a root can be so much affected and yet give so little evidence of loss of nerve conduction. It is, of course, true that a lesion of the first sacral root only would be compensated *fairly fully*, but that there should be no definite physical signs whatever except a little diminution of the ankle jerk is surprising. Apparently the [illegible] intact. Further evidence will be given under the disc

the sciatic nerve

edicine Sciatica

In these sections

the blood vessels were engorged and some showed small-celled infiltration around In addition there was swelling and thickening of the epineurium. The organisation of the exudate presumably leads to adhesions round the nerve, but there were none in this case. Cohen

ibstantial

r, stated

that when working with the late Sir [illegible] saw three swollen inflamed sciatic nerves exposed at operation. Brown (1944), in the same correspondence in the *British Medical Journal*, quoted *James Collier, the foremost* neurologist of his day. Collier was describing what he had himself seen at operations performed for the

relief of sciatica He saw a nerve which was pink and swol
distended with œdematous fluid and adherent to its surround
structures He said this inflammation might be local and not invo
the whole nerve, or it might spread widely Purdon Martin (19
also considered sciatica to be an interstitial neuritis Walshe (19
was of opinion that acupuncture of the nerve acts by puncturing t
sheath of the nerve and allowing the escape of inflammatory exuda
This evidence is unimpeachable, and to a point convincing The
is no doubt as to the pathological evidence which is the ultima
and inevitable criterion

As against this, the usual evidence of "neuritis" is mostly wanting
Apart from polyneuritis, or peripheral neuritis, it is unusual to see th
usual triad of neuritis, weakness, loss of reflexes, and wasting o
sensory loss It is clear that if neuritis exists it is of the interstitial
variety and not parenchymatous This is agreed by all competent
authorities The nerve sheath is the first point of attack, and the
inflammation spreads into the connective tissue lying between the
nerve bundles and so produces pain and disability Although the cause
is not understood this makes an understandable picture It is
quite uncertain whether this is bacterial toxic, or constitutional in
origin The physical signs in the case of root involvement may be
indistinguishable (as Holmes and Sworn concluded) from the pro-
trusion of the intervertebral disc This process may occur either in
the roots of the nerve or in the trunk of the nerve itself In all
probability it is a self-resolving lesion, and has a definite term
Perhaps it may be far more common then we think to-day and account
for a proportion of cases far in excess of the present day estimate It
could be compared with Bell's palsy of the seventh nerve, which has
many similarities but unfortunately many diversities For instance,
Bell's palsy is seldom painful, whilst pain is the outstanding symptom
of sciatica

Sciatic neuritis must not be dismissed entirely, but it must be
regarded as uncommon by *present-day knowledge*

Causes in the Vertebral Column

Inflammatory or Neoplastic Disease
Paget's Disease and other Diseases of Bone
Ankylosing Spondylitis
Osteoarthritis of the Spine
Transverso-sacral Arthritis

These can be mostly separated by X-ray In cases of ankylosing
spondylitis the sacro-iliac joints must always be X-rayed

Transverso-sacral arthritis is the name applied to a syndr...
back pain with sciatic radiation connected w...
the transverse process of th...
Ingebrigtsen ... f
of the t... i
arthrect...

... by an

In the Pelvis

Pelvic Tumours
Fibrositic Lesions of Muscles which support the Nerve
Late in Pregnancy through Pressure

X-rays with rectal and vaginal examinations will exclude pelvic tumours

It is possible that fibrositic lesions of the supporting muscles may lead to sciatica It is impossible to prove or to disprove but it is a possibility which cannot be neglected. It is conceivable that such a lesion might account for many cases of sciatica

In the Thigh or Buttock

Hip Joint Disease associated with Sciatic Pain

This must be placed among the rarer causes of sciatica Perhaps it occurs most commonly in connection with osteoarthritis of the hip but is often seen in ankylosing spondylitis when the hip joint is involved. Taking all cases together this is an uncommon cause

In the Feet

Pes planus is an undoubted cause of pain in the buttock, thigh and leg The number of such cases is undoubtedly small, but become chronic unless suitably treated There is generally some unusual aspect in the case which warns that a specially detailed examination, including the feet, must be made

SCIATICA COMMONLY MET WITH BUT OF DOUBTUL ORIGIN

Of Central Origin

Psychogenic sciatica may be a real entity. Its frequency and importance seem to vary in direct relation to the psychological bent of the observer.

Many cases undoubtedly have their origin in events which have a depressing effect on the patient, such as the loss of a dearly loved wife, or an unfortunate financial disaster In the London blitz of 1940 many fresh cases occurred and many old ones relapsed *Sciatica* apparently due to a neurosis, or at any rate with a marked functional overlay, was seen very commonly in soldiers during the war Points
which make one suspicic
nothing in the way of
marked scoliosis which p
spine These cases seem to be stiff from the action of voluntary muscles, in other words, *to hold themselves stiff*, and perhaps to be unable to relax. It was in this type of case that surgical operation was so unprofitable. Possibly fear and anxiety were the basal factors, certainly some of the men were not of the malingering type This type of case is occasionally seen amongst civilians.

In the Cord Space

Extramedullary Tumours
Protruded Intervertebral Disc and/or Herniated Nucleus
? Hypertrophy of the Ligamentum Flavum

The protruded disc is a type of extramedullary tumour, so they will be considered together. Hypertrophy of the ligamentum flavum is an uncertain entity at the present time, but views on this will also be expressed.

The Lumbar-disc Syndrome

The intervertebral disc consists of a tough fibrocartilage, the annulus fibrosus, attached firmly in a ring-form round the vertebræ and enclosing a semi-fluid mass under tension, the nucleus pulposus, which represents the remains of the notocord

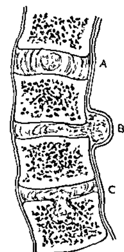


FIG 214

A diagram to show at (A) the normal nucleus and disc, at (B) a posterior herniation, and at (C) herniation into a vertebral body

In 1934 Mixter and Barr described herniation of the nucleus pulposus in connection with the sciatic syndrome The first protruded intervertebral disc was described by Kocher in 1896

The intervertebral discs have received intensive study since then and are fully described in the chapter on Applied Anatomy

The whole difficulty now lies in the question of diagnosis What are the special points which must be brought out in the clinical examination of a case which would make the physician suspect that a disc protrusion is present? A careful study of the literature makes it clear that opinion is very divided on this question, so that one must be guided by personal experience

Points which make the Diagnosis of Disc Protrusion a Possibility

Type of onset is important The patient who had an accident and injured his back a few months ago, and quite suddenly developed severe backache two or three days ago, which went into his leg the next day, is a likely type It suggests a protrusion, especially if the pain is very severe and he can hardly move in bed Compare that with the history that there has been no accident of any kind and that for several months there has been a little sciatic pain which is worse as the day draws on A story of *recurrent pain in the back* with intervals of complete freedom is suggestive, more especially if it appears that on one or more occasions the sciatic pain *disappeared suddenly* This is almost pathognomonic of a disc.

Age of patient is really of little help The young man is supposed

to have his protrusion because he is a harder worker more likely to suffer trauma, and for no other reason. Protruded discs are as common between the ages of 40–50 years as between 20–30 years of age

Posture is important as it represents repeated microtrauma to the low back.

Radiation of pain in all types of sciatica is down the back of the thigh to the lateral aspect of the leg and the outer part of the sole of the foot Tender spots are little guide, either.



Fig 215

A case of sciatica showing the list of the lumbar spine and the poor posture with apparent protrusion of the right hip This was a case of fibrositic sciatica.



Fig. 216

A likely case of prolapsed nucleus pulposus The lumbar spine has gradually flattened and is on the point of becoming kyphotic

Physical Signs

A *positive Lasègue* and a *missing ankle jerk* may both be found in any case and no conclusion can be drawn Poor forward bending and a stiff lumbar spine are very common.

Apparent *loss of strength* is very often due to pain. Really weak flexion of the big toe, however, makes one suspicious and real muscle atrophy more so

Lumbar signs such as severe pain, a rigid spine and scoliosis taken together are suggestive A spine which is gradually losing its lumbar lordosis and becoming kyphotic is a strong indication that the mechanics are upset by a protrusion *Aggravation of the pain by coughing and sneezing* has no differential value as it occurs in many

aggravation is due as much to the muscles used in coughing and sneezing

Tenderness over the lumbar spines on percussion seems to have varying value and is hard to assess Some have great regard for it

Parasthesiæ and numbness are important indications as these seldom occur in fibrositic cases Genuine *sensory loss* comes into the same category but is very uncommon

O'Connell (1946) thinks the drop test and the femoral nerve-stretch test helpful

X-RAY AND LABORATORY AIDS

The X-ray in most cases of sciatica of doubtful origin is normal Gross changes such as tuberculosis, neoplasm and Paget's Disease have, of course, been ruled out There are, however, a few in which loss of joint space occurs between two vertebræ and in these rare cases the X-ray may help to settle the issue The cases in which arthritis of an apophyseal joint is shown are also helpful

Radiopaque myelography has been almost entirely given up now There is no doubt that it led to considerable reactive phenomena without providing adequate information If used, pantopaque is now the preparation of choice Air myelography is less damaging but not much more helpful

Cerebrospinal-fluid examination is seldom of great use If samples are taken (as we used to do) from L3–4, L4–5 and L5–S1 the damage done by the needle is considerable and the information obtained seldom decisive However, a moderate rise in the protein content (50–100 mgrm per ml) is sometimes of great assistance

Summary on the Lumbar Disc Syndrome

All the important points have been mentioned Clearly it is only by a combination of these various points, assisted by a ripe clinical judgment, that it will be possible to arrive at a reasonably correct assessment of the situation In order to present some idea of the significance of lumbar disc protrusion the table below shows the effect of conservative treatment of sciatica before the operation on protruded discs was used

The Prognosis of Sciatica Treated Conservatively

This series comprises 58 cases treated between 1931 and 1939 before any of the cases were operated upon for prolapsed disc Four cases were diagnosed as suffering from neoplasm, these are excluded, as they all died Conservative treatment rendered 35 patients symptom-free substantially improved 12 others, and did not improve 7 cases The duration of treatment is given in the table overleaf

The modern view is that at least three months' conservative treatment should be given, even to cases which are more than likely to be caused by protruded discs If this criterion had been applied, probably 9 cases would have been operated on This would represent

17 3 per cent. and would leave 82·7 per cent. of cases rendered either symptom-free or improved by conservative measures There are many figures with which this could be compared if adjustments were made, but no strictly comparable table.

	Weeks						*Years*			
	2	4	6	8	12	16	1	2	6	
Symptom-free	4	4	9	3	8	4	1	1	1	35
Improved		3	3	1	2	2	1½	.	..	12
Not improved .				..	2	1	1½			5

It may be as well to break off for a moment here and discuss the signs which localise the root involved This is of the greatest possible importance in the consideration of those causes of sciatic pain which occur in the cord space and which need care in diagnosis.

Signs which are said to localise the Root involved

Quite clearly it would be of the utmost value if indications could be given as to what is to be expected when any given root is involved The overlap of roots and the consequent compensation of

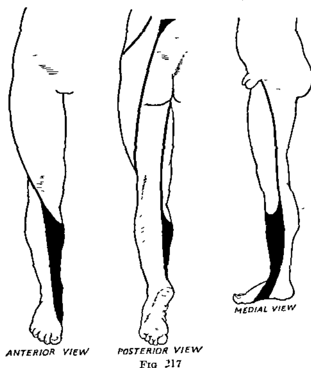


Fig 217

Approximate dermatome of the fourth lumbar root.

(After Bradford and Spurling)

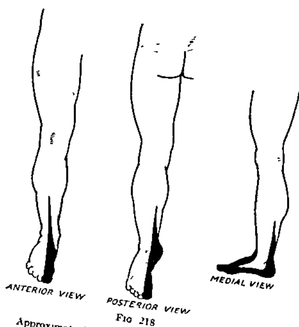


Fig 218

Approximate dermatome of the fifth lumbar root

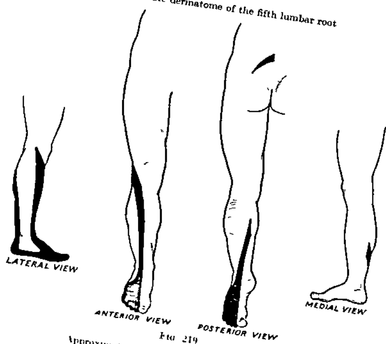


Fig 219

Approximate dermatome of the first sacral root

(After Bradford and Spurling)

The three figures (217, 218 and 219) show average findings when the respective roots are involved. They should be compared with Figs 220 and 221, which show somewhat unusual findings

established lesions make this impossible at the present time, but *O'Connell (1946) has set out a table* which records his experience in this field. His account is based on a personal series of 220 proved (presumably at operation) cases of lumbar intervertebral disc protrusion, treated over seven years, and so must be regarded with considerable respect.

TABLE INDICATING THE COMMON CLINICAL FEATURES OF LUMBAR DISC PROTRUSIONS AND EMPHASISING THE SIGNS OF LOCALISING VALUE

Level of Disc Protrusion	*L5–S1*	*L4–L5*	*L3–L4*
Extradural nerve related to protrusion	1st sacral	5th lumbar	4th lumbar
Site of pain	Posterior crural → sole and lateral margin of foot	Posterior crural → dorsum and medial margin of foot	Anterior crural → medial malleolus
Site of paræsthesiæ	Sole of foot	Dorsum of foot	Subcutaneous surface of tibia
Spinal deformity	Lumbar lordosis diminished	Lumbar lordosis diminished	Lumbar lordosis diminished
Spinal mobility	Flexion gross reduction Extension slight reduction	Flexion, gross reduction Extension slight reduction	Flexion slight reduction Extension reduction more severe than with lower lesions
Straight-leg-raising test	+ +	+ +	− (+)
Drop test	+	+	−
Femoral nerve-stretch test	−	− (+)	+ +
Motor disturbance	Wasting and loss of tone in glutei, hamstrings, and calf Weakness in hallux	Wasting and loss of tone in glutei, hamstrings, and calf. Weakness in hallux	Wasting, loss of tone, and weakness in quadriceps
Dermatome in which sensation may be diminished	S1	L5	L4
Reflex change: Knee-j.	+ +	+	− (+)
Reflex change: Ankle-j.	− (+)	+ −	+ +

O'Connell (1946).

Spu

for

Their view is that as only one spinal nerve is usually involved by a protruding disc, it may be worth while to make that nerve incapable of carrying painful impulses. To implement that purpose they suggest posterior rhizotomy within the dural sleeve proximal to the spinal ganglion. The only deleterious effects are numbness and sometimes a small area of anæsthesia. They say that although there is awareness on the part of the patient of altered sensation causalgia never follows, and the change is not annoying for the patient. The pains are not unlike those of tabes dorsalis but are only fleeting



Fig 220

Dermatome of the fifth lumbar root (modified) from Bradford and Spurling As the result of posterior rhizotomy these authors worked out the approximate distribution of the changes found after section These diagrams and Figs 217, 218, 219 represent findings in certain cases From these it can be deduced that the lumbar dermatomes vary a great deal in different patients See Figs 217, 218, 219 for "average" findings in each dermatome



Fig 221

Distribution of the first sacral root in a case of posterior rhizotomy

(Modified from Bradford and Spurling)

in character. The anterior root is not apparently affected by the posterior rhizotomy, and it seems that even if it is crushed by a needle-holder it produces changes no greater than may be found in the usual post-operative case. Root crushing (Bradford) gives as satisfactory clinical results as posterior rhizotomy, but in Bradford's view is not as *surgical* a procedure. So far as can be ascertained, this is an original procedure, but certain important physiological facts have been obtained from posterior rhizotomy.

DIFFERENTIAL DIAGNOSIS BETWEEN FOURTH LUMBAR AND LUMBOSACRAL HERNIATIONS

Fourth Lumbar Disc (*L5 root*)	*Lumbosacral Disc* (*S1 root*)
Paræsthesiæ of great toe and anterolateral leg	Paræsthesiæ of lateral foot and posterolateral leg
Slight paresis of *extensor of great toe or* of tibialis anterior	Slight paresis *of Achilles muscle group*
Hypesthesia of great toe and anterolateral leg (or spreading paresthesias on stimulation)	Hypesthesia of lateral foot and posterolateral leg (or spreading paresthesias)
Rarely diminished ankle jerk	
Paravertebral pressure or percussion at fourth lumbar interspace produces radiating phenomena	radiating phenomena

Bradford and Spurling (194?)

Some pictures (modified from Bradford and Spurling) are reproduced to show the effects of posterior rhizotomy (Figs 220 and 221)

From these very interesting observations certain provisional conclusions can be drawn. The dermatomes of the different roots vary greatly in individuals, this is in harmony with previous experience and explains many of the difficulties of the past Section of one posterior root apparently leads to no great change as overlapping compensates for the loss. This seems to deal effectively with previous doubts expressed in this chapter. The findings here demonstrated do not agree with previous experience as shown in the diagrams.

Hypertrophy of the Ligamentum Flavum

This was at one time considered a frequent cause of sciatica and Brown (1938) reported seven cases in which the ligament was compressing nerve roots [illegible] College [illegible]

cases sections showed abnormal white fibrous tissue formation in [illegible] ligament As the ligament derives its nerve supply from the posterior primary divisions of the spinal nerves, it may cause "referred pain" At the present time opinion is rather hardening against the idea of a hypertrophied ligamentum flavum causing symptoms by itself, but personal experience suggests that this may be a passing phase

In the Vertebral Column

Apophyseal Arthritis
Spondylolisthesis and Congenital Spinal Defects
Sciatic Pain due to Malalignment of the Spine and Postural Conditions

Spinal apophyseal arthritis associated with sciatica —The direct association of spinal arthritis of the posterior joints with sciatic pain was suggested by Professor Putti in 1936 but had previously been mentioned by him in an article in the *Lancet* in 1927 In this country Bankart has been a strong protagonist of the idea

The apophyseal joints are a direct posterior relation of the nerve canals, and so the two are brought into fairly intimate contact It could well be on theoretical grounds that arthritis of these facet joints produced mild inflammation of the nerve roots The great difficulty in accepting the theory is to provide a reason why these particular joints should so often become arthritic and why the result is sciatica only Various reasons have been suggested to clarify this problem It has been said that congenital anomalies occur with great frequency and that they are often asymmetrical, so leading to mechanical

posterior or coronal plane and so may not be visualised unless specially looked for

Putti first performed the operation of removing the "facet joint" at the lumbosacral junction Here the fifth lumbar root lies directly anterior to the posterior articulation between the fifth lumbar vertebra and the sacrum Removal of this articulation was thought to have two effects it disposed of a joint which was arthritic and it allowed more room for the lumbar root in its rather cramped quarters Certain essential features must be present before the operation is contemplated Pain must be severe at the lumbosacral articulation, the X-ray must show a narrowed lumbosacral disc *and* arthritic changes in the spinal articulation, and no *severe* neurological change must be present The operation is often coupled with lumbosacral fusion Conservative treatment should certainly precede operation by many months

There is no doubt that the anatomical possibility exists, that the

into consideration, and considering their relationship with the results of operation on protruded discs and herniated nuclei, it can only be concluded that arthrectomy holds a place in the treatment of sciatica but probably not a very important one

Spondylolisthesis and congenital spinal defects —Sciatic pain occurs in about 10 per cent of cases of spondylolisthesis Spondylolisthesis is an uncommon condition and difficult of exact diagnosis Taking all cases of sciatica together it is an uncommon factor

Steindler (1929) stresses the limitation of movement in the lumbar spine and this is a fairly constant feature in advanced cases. The Lasègue test is often positive on account of the spasm of the hamstrings, *but the pain is predominantly in the back*, the sciatic radiation is a secondary and rather unimportant point in the syndrome. X-rays will usually settle the issue

Congenital spinal defects include such things as sacralisation of the fifth lumbar vertebra and a narrowed lumbosacral disc. Although they may have some effect in altering the path of exit of the fifth nerve, they are generally regarded to-day as *predisposing conditions* only.

Sciatic Pain due to Malalignment of the Spine and Postural Conditions

It is clear from what has been said already in this book that these conditions have an unsettled rôle in the production of secondary signs and symptoms. The matter is fairly fully discussed in the section on posture

The segments of origin of the sciatic nerve make it evident that mischief arising in bony segments L3, 4, 5 are those with which we are chiefly concerned It will be remembered that the anticlinal or "plumb-line" vertebræ are L3 and L4 It is therefore in accordance with the facts to think that L3 and L4 will not show maladjustments of posture but that L5 might Further, as we have seen, malposition of one nerve root is as a rule fully or nearly fully compensated The reason for this is not understood, but if any trust can be placed in these observations, it does not seem likely that faults of posture and malalignment of the spine, whatever else they may do, cause sciatic pain in any appreciable proportion of cases Some authoritative opinion is opposed to this view, but on the whole such evidence as *is available* favours it.

In the Thigh and Buttock

Fibrositic Lesions affecting predominantly Psoas, Glutei, Pyriformis and Hamstring Muscles. Trigger Points in the Back
A Sacro-sciatic Band
Syndrome of the Tensor Fascia Lata and Iliotibial Band
Accidental Injection in the Course of Treatment of Various Disorders
Interstitial Neuritis of the Nerve Trunk

Fibrositic lesions.—Some authors quote the psoas and quadratus lumborum muscles as being the site of fibrositis which leads to sciatica. One author goes so far as to say that if the patient is supine, and complains of pain when the trunk is flexed against resistance, the diagnosis lies in an affection of the quadratus lumborum *It is possible* that these muscles are the seat of fibrositis but it is difficult to prove, and at present there is no known way of doing so The *glutei* are a frequent source of tender spots and nodules. The great majority give pain only at the site of the nodule, but some produce pain radiating down the sciatic distribution. The *posterior sacral ligaments*, with

their unusual nerve supply, have very much the same characteristics. In fifty cases of gluteal fibrositis only six gave a sciatic radiation, so

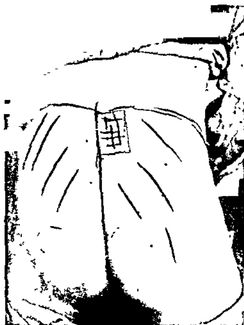


Fig 222

Fibrositic Lesions

A case of fibrositic sciatica showing the area of tenderness found (marked with oblong) The radiation of pain was down the right sciatic nerve

more frequently in the outer third, a good many occur at the origin of the muscle.

In investigating this question with the late Sir Thomas Lewis, Kellgren injected various points with 6 per cent saline and noted the radiation of pain Injection of the supraspinous ligaments led to local backache only, but if the deep interspinous ligaments were injected sciatic radiation also occurred

Various points in the glutei have been injected with 6 per cent saline and so far in only three cases has sciatic radiation been found which could be relieved by injection of procaine in the same spot

Referred Pain

This subject was originally studied in connection with visceral disease, and it was demonstrated that visceral pain was referred to

position it steadies the pelvis on the lower limb. The superior gluteal nerve as a rule enters the thigh above the pyriform muscle

Its action and nerve supply make a possible explanation. This is one of the muscles which in common with the glutei is almost constantly in action, and perhaps its constant involvement makes a "fatigue" explanation possible. Its nerve supply is intimately related to the pyriformis and possibly becomes involved in connection with that muscle. Ober devised an operation to divide the fascia, but no personal experience can be given.



FIG 223

Fibrositic Lesions

A case with some sciatic pain referred down the iliotibial band in the first place. This is a type which was described by Ober and may either be purely local or radiate down the whole of the sciatic nerve. The pear-shaped marking is the area of great tenderness and the line with crosses the radiation of pain.

Interstitial Neuritis of the Nerve Trunk

The pain is felt in the back of the leg, in the calf and outer part of the foot. The nerve trunk is tender on pressure and may be felt in some cases. Tender points are the lower border of the gluteus maximus and the neck of the fibula. Barnes Burt (previously quoted) takes the view that the "floor" sign is diagnostic if there is no arthritis of the knee. The patient sits on the floor with his back against a wall, so fixing the pelvis and reducing the spasm of the hamstrings. The sign is positive when the back of the knee cannot be made to touch the floor.

This is an unusual form of sciatica but, so far as a small [illegible] expectations

in accident, nerve may ing gluteal

injections

In the Back

Fibrositis of the Posterior Sacral Ligaments and of the Erector Spinæ

Pain referred down the leg may occasionally be found in association with tenderness and small nodules over the posterior sacral ligaments.

These include both the short and long posterior sacro-iliac ligaments which are contiguous to and in some cases interdigitate with the sacrotuberous and sacrospinous ligaments These are troublesome to treat as they occur over a fairly large area and their response to injection with procaine is very poor Most of such ligaments are supplied by the posterior primary divisions of the spinal nerves and so are a potential source of referred pain It is said that the *fourth lumbar nerve does not supply these particular ligaments.* If this is so it seems of little help in the diagnosis of such cases as the area of referred pain is much the same as in other cases

It is not at all uncommon to find an area of tenderness or even a nodule in the *lateral border of the upper third of the erector spinæ,* and treatment directed to this source sometimes has unexpectedly pleasant results

Some authors name *other sources* of sciatic pain referred from the back, but no personal experience is available

In the Leg

A large nodule sometimes appears in the gastrocnemius, which may mimic the referred pain of sciatica. The diagnosis is generally obvious

Sciatic Causalgia occasionally occurs in the distribution of the tibial component of the sciatic nerve It is comparable with causalgia of the median nerve *Focal sepsis* is an occasional factor On two or three occasions a case of sciatica has completely and permanently cleared up after the extraction of a tooth which was the site of an apical abscess

TREATMENT OF SCIATICA

In the Acute Stage

Treatment is entirely symptomatic and palliative. Some of the worst cases of sciatica are those in which treatment of an active and energetic nature has been given in the acute stage

Rest in bed is essential

Immobilisation by various methods used to be practised but it is quite impracticable With severe sciatic pain the patient should be allowed to lie in whatever position he finds most comfortable A very good position in bed is to lie on the back with the knees flexed over a pillow and the feet up against a bed-board By pressing gently on the board the pain may be considerably eased. Occasionally the acute febrile type of onset described by Cohen may occur, salicylates appear to help here In a few cases morphia or dilaudid may be required, but Mist A P C seems to answer the purpose well and is usually adequate Barbiturates help the patient to sleep if the pain is not too severe

Physiotherapy can assist only by very mild measures Whether *heat* will help can be told only by trial and error, some cases are made much worse and some much better If heat does not help, anodal

galvanism given with a large pad over the buttock is sometimes of great help Only a very small current should be used

If neither do well, the limb may be painted with glycerine and belladonna, or *Benguès balsam* may be gently applied. Procaine injection subcutaneously into the painful spots is useless When the pain returns it is worse than it was before.

Oxygen injection into the length of the thigh sometimes is very useful.

A small transfusion syringe with a hollow piston should be used The piston is connected to an oxygen cylinder with a fine adjustment and the tap on the piston turned off. The needle is then pushed through the skin until the point is subcutaneous and suction is made to be sure the end is not in a vessel. The tap of the piston is then opened and the oxygen allowed to flow until the skin is well ballooned The needle is withdrawn and exactly the same procedure is carried out at various places down the thigh. This procedure, which may sound very simple, is described in detail, as death may follow the sudden intravascular injection of oxygen. With the method described above, no such disaster can occur.

If progress in the *acute stage* is very slow, two other measures may help Sutton (1939) published a series of cases in which intravenous injection of 20 c c of a solution containing 15 gr. sodium salicylate and 15 gr. sodium iodide produced amelioration. One or two injections are given at an interval of days. Occasionally this is useful, but *it is better to use the solution at half-strength*

Another method of which personal experience is available, but which has not been published, is injection round the lumbosacral [illegible] The needle is directed [illegible] Immediate and lasting [illegible] ed until toward the end of the acute stage About 40 c c. is injected

In the Chronic Stage

Treatment will naturally depend on what is *thought to* be the cause of the pain An attempt has already been made to describe those signs which are thought to be suggestive of a protruded disc or herniated nucleus In these cases conservative treatment should be carried out fo[illegible] considered

The *results o*[illegible] urling published a series o[illegible] fortunately few further results are published in the 1945 edition of their book Of these 166 cases four cases had to be operated on again and four had recurrences similar to the first attack. *In the reoperated* cases a herniated mass was again found and removed, with further relief of symptoms Love (1938) reports 150 cases with one recurrence [illegible]

[illegible] Hawk

(1936) reported rather poor results in the early days. Spinal fusion, of course, adds considerably to the difficulties and delays of the operation and generally means months in hospital

All the references for this section are in Bradford and Spurling's (1945) book *The Intervertebral Disc*

Charles Gray (1946) in a series of 125 operation cases included 55 arthrectomies and 70 laminectomies Of the 55 arthrectomies, 39 showed complete and immediate cure, and 25 showed a *complete* and *lasting* cure, apparently attributable to the operation

Of the 70 laminectomies the findings were as follows

Group 1 Prolapsed intervertebral disc, 40 cases
Group 2 Thickened ligamentum flavum, 14 cases
Group 3 No pathology found, 15 cases
Group 4 Spondylolisthesis, 1 case.

In Group 1, of 23 civilians, 21 were cured immediately, and 11 showed complete and lasting cure, of 17 soldiers, none showed complete cure, 5 were improved and 12 were failures

In Group 2, 10 were immediately cured, and 5 showed complete and lasting cure

In Group 3, 3 showed complete and lasting cure

In Group 4, spinal fusion produced partial relief.

Gray concludes, in words which bear a refreshing imprint of balanced expert judgment "so far as the prolapsed intervertebral disc is concerned, we are surprised less by our own failures than by the so frequent successes of some surgeons who claim a very high proportion of successes after laminectomy The possible causes of persistence or recurrence of pain after the operation are obvious—a further protrusion of disc material at the original site may occur . Excision of a definite protrusion which is impingeing on a nerve root relieves pressure, and removes the immediate cause of pain, but does not restore the parts to their normal condition An incomplete and degenerate disc is left behind "

So far as personal experience goes, Gray has said the last word on protruded discs and herniated nuclei The operation, in skilful hands, is a godsend to many crippled people, the comparatively long convalescence is a small price to pay for the relief which the surgeon gives, but the chances of success are as Gray describes

Treatment of Chronic Cases of Sciatica after Operation has been considered and rejected

This sub-section title naturally assumes that three months' conservative treatment has been given, has been unsuccessful and that the question of operation has been negatived The section will therefore be divided into

1 Three months' conservative treatment of chronic sciatica before the question of operation has been decided
2 Treatment after the failure of three months' conservative treatment and when operation has been rejected.

1. Conservative Treatment of Chronic Sciatica

A good deal will depend on the physical signs present and it i convenient to divide the cases into two classes:

(*a*) *High sciatica.*—This will include those cases with some lumba signs, such as pain in the back and a stiff spine. These case may sometimes be associated with painful local areas in the fasciæ ligaments, or muscles. The first thought here will naturally be to anæsthetise the spots complained of or found, and observe the effect Injection of these spots or nodules with 0 5 per cent. procaine may temporarily affect the pain, generally it will take three or more injections accurately localised before anything more than a temporary effect is obtained In the case of the posterior sacral ligaments no effect may ever be obtained. The next step is to try the effect of counter-irritation, and the Kromayer lamp (see Chapter XXXV), given in a suberythema dose, is the treatment of choice If this fails and the general posture, standing, is good, radiant heat and massage may well be tried. If this fails too, the question of epidural injection and manipulation must be considered Very occasionally, in cases with a protruded disc or a herniated nucleus, manipulation has been known to lead to paraplegia Two such cases have been seen in the last ten years, and no doubt such an outcome is extremely distressing The best safeguard is not to proceed to epidural injection and manipulation without expert orthopædic consultation. The diagnosis of a protrusion is not exact, but with experience the *likelihood* of a *protrusion can be foretold with some accuracy, and the reason* for withholding operation is not so much a doubt as to the diagnosis, as to the fact that many protruded discs resolve their own symptoms. Therefore, nothing must be done to increase the patient's risk, and when, after consultation, a disc is considered to be a likely or possible diagnosis, manipulation should not be carried out.

If the spine is stiff, the Lasègue is positive, fibrositic areas have been ruled out, and the treatment already detailed, even with the addition of exercises and the use of Guthrie Slings, is ineffective, epidural injection and manipulation are the treatment of choice. Further details as to these manœuvres are set out in the Appendices No doubt has ever been cast on the effectiveness of this treatment, and it is fully or nearly fully successful even to-day in the large majority of cases. It is essential, however, that this treatment should be followed immediately by *active* and *passive* exercises, carried out to the limit of endurance With this proviso a good deal of confidence may be felt in the outcome Should this fail, and *operation still* be rejected, the question of the pyriform, levator and coccygeus muscles should be considered. The diagnosis here has been fully dealt with. I remains to infiltrate these muscles *with procaine* where po observe the result. No doubt the shor r t uff ma rce of great trouble, and various s ggest to relieve these conditions. On s nosed the history of

[illegible] h fibrositis of the hamstrings, [illegible] be borne) should be tried first [illegible] ures which give the greatest relief are stretching of the sciatic nerve and injection into or as near as possible to the sheath of the nerve. The best plan is to give pentothal and do both

The nerve emerges from under cover of the gluteus maximus just to the medial side of the mid-point between the ischial tuberosity and the great trochanter. This is a good surface marking to take, as it lies fairly superficially at this point An alternative plan is to take a point at the junction of the middle and outer thirds of a line joining the posterior superior spine of the ilium with the tip of the great trochanter The needle is inserted at either of these points and pushed in until it is touching the sciatic nerve This point may sometimes be easily determined as the foot twitches when the needle touches the nerve About 100–200 c c of normal saline is injected at this point After this the nerve is stretched by flexing the thigh with the knee extended Occasionally adhesions can be felt to part in the interfascial plane

2. Treatment after Three Months' Conservative Treatment if Operation has been rejected

These may be regarded as the really "chronic" cases which treatment has failed to relieve, and which our present knowledge is insufficient to help.

Although the prospect of "cure" has vanished, or is vanishing, there are still helpful measures available These patients have generally developed a scoliosis of considerable degree by this time and one leg is usually flexed at the thigh A general "hang-dog" expression is apparent and often great loss of weight *Psychological assistance* is urgently needed to combat the very natural, but at the same time oppressive, gloom which surrounds the patient. *Psychotherapy* of the professional type as a rule makes matters worse, and it is only by an effort to improve the general environment that amelioration will ensue It is very evident in these patients that continuous pain is at the root of their trouble, and that this is made worse by their inability to adapt themselves to changed circumstances, and by a continuous dwelling on their affliction

Head suspension is very useful Using an ordinary helmet-type headpiece they are suspended with periods of rest, for an hour a day This allows the weight of the body to be used as a method of straightening the distorted spine It is a useful measure and has been known to restore to full activity

Active exercise having failed in the initial period is unlikely to succeed now but combined with fairly lively faradism to the (very often) contracted and spastic muscles often does good

Rectal or intrapelvic diathermy has been known to help It promotes the blood flow to the lumbosacral plexus and so may have some physiological foundation As a last and rather drastic step a low spinal anaesthetic may sometimes produce relief

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(*b*) *Low sciatica* may often be diagnosed early in the history of

the case It is generally associated with fibrositis of the hamstrings, so that massage to these parts (if it can be borne) should be tried first These cases are uncommon The measures which give the greatest relief are stretching of the sciatic nerve and injection into or as near as possible to the sheath of the nerve The best plan is to give

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The treatment of sciatica of doubtful origin may be one of the most difficult problems in medicine, but the great majority recover full activity after treatment.

ACROPARÆSTHESIÆ IN THE LOWER LIMBS

In the chapter on Brachial Neuralgia the question of acroparæsthesiæ in the upper limbs has been dealt with, but recently Purdon Martin (1946) has described unexplained pains in the legs at night. He gives three case histories and saw other cases during the war. The symptoms of all the cases are approximately the same and consist of both paræsthesiæ and pains in the legs at night If severe there may be tenderness of the calves. Physical examination, as in the case of the arms, is entirely negative Most of the cases occur in middle-aged males, but one doctor aged twenty-six recorded that he suffered from a similar malady

So far as ætiological factors can be identified, the pains seem to follow excessive exercise or long hours of standing during the day. The muscular tingling can be relieved by exercise and the burning pain in the feet by placing them against something cold

Although general opinion is that acroparæsthesia in the upper limb is due to some obstruction at the thoracic inlet Purdon Martin can find no similar explanation in the legs. It is, however, possible that the *sacrosciatic band* already described could have some such effect, but there is no evidence for or against

Martin finds 10 gr of aspirin at night and/or in the morning largely relieves the symptoms.

Restless Legs

In 1945, Eckhom described a condition under the above title.

A short account is given here because the painful form may be confused with the sciatic syndrome. The paræsthetic form is, however, the more common

In the painful form the patient complains of pains in the calves which sometimes are also felt in the thigh The pain is often long continued but remissions always occur. Paræsthesiæ may occur in either form, are particularly disagreeable and have the same distribution as the pain

In either case restless movements occur in the legs, which vary between involuntary movements of a slow and rhythmic character and rapid jerks which are almost tetanic in character.

The sensory phenomena are associated with the motor characteristics in a small proportion of cases No physical signs are found but the reflexes are all exaggerated during an attack.

In those cases where the sensory side is paramount it is said that carbachol 2 mg four times daily relieves the condition. The cases with motor symptoms are said to be helped by chewing a tablet of gr. 1/100 nitroglycerin, so the condition may be thought to be vascular in origin.

From personal experience it is believed that both these syndromes

exist, but the remedies advocated are not uniformly successful It is likely that weakness in the legs due to arthritic conditions in the knee (or perhaps any other cause) may bring on the symptoms in either form Those interested in locomotor disorders will find the syndrome reproduced in cases of two types The first concerns cases of rheumatoid arthritis of the knees with muscle-wasting, the second is found in connection with cases where a cartilage has been removed and an unstable joint is left behind. In these cases particularly, the tetanic type of movement is seen

The differential diagnosis from sciatica is clearly not difficult, provided that the syndrome is known, but the separation of cases from those of polyneuritis and sub-acute combined degeneration of the cord depends on the physical signs and the realisation that the symptoms in the one case are remittent and the other almost continuous

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CHAPTER XXX

BRACHIAL NEURALGIA

THE term brachial neuralgia is applied to conditions which cause pain to be present in or referred down the components of the brachial plexus *By definition this term includes a variety of* ætiological causes, the separation and relative importance of which is as yet uncertain Brachial neuralgia being non-committal as to cause is preferable to brachial neuritis, which implies a specific pathology

In a series of 1,300 cases complaining of rheumatic disorders (Fletcher, 1944, unpublished), 24 *cases were diagnosed as suffering* from brachial neuralgia as against 73 cases from sciatica

In this chapter polyneuritic syndromes will not be considered, nor will myalgia or diseases of the shoulder, as they are dealt with elsewhere As with sciatica, it is helpful to classify the causes of pain in and referred down the brachial plexus under a regional anatomical basis In this manner the pathological possibilities at any particular stage in the course of the nerve are reduced to manageable proportions

Important lesions causing pain in the arm are marked with a star, whilst those of unusual importance are additionally underlined

Recent papers have, as in the case of sciatica, cast doubt as to whether neuritis exists, since many cases formerly diagnosed as suffering from this complaint have been shown *to have associated* causative factors. This contention cannot be answered by pathological examination as practically no material exists. Over the past few years "epidemics" of brachial neuritis have been reported (Spillane, 1943, Dixon and Dick, 1945, Turner, 1944, Wyburn-Mason, *1941) Study of these reports, in particular that of* Spillane with reference to the possibility of certain specific lesions, to be considered later, as being causative in this syndrome, leads to the conclusion *that* on the present data, brachial neuritis has a specific existence This conclusion is an important one as it is very tempting to discard an *entity with so little* [illegible] vague ætiological factors a[illegible]

Brachial neuralg[illegible] dings.

I. CAUSES IN THE SPINAL CORD

1. **Intramedullary Tumour** *
2. **Amyotrophic Lateral Sclerosis**
3. **Syringomyelia**
4. **Sub-acute Combined Degeneration**
5. **Hemiplegia**
6. **Myelitis**
7. **Premonitory in Infectious Disease**

Tumour is dealt with in Section II, as the *distinction* between intramedullary and extramedullary growths is often impossible It

is to be noted that many diseases of the central nervous system not characteristically associated with pain may commence with this as a presenting feature, syringomyelia, etc Occasionally pain down the arm is seen as a premonitory symptom in epidemic encephalitis

II. CAUSES IN CORD SPACE

1. **Extramedullary Tumour ***
2. **Prolapsed Intervertebral Disc ***
3. **Syphilitic Pachymeningitis**
4. **Localised Arachnoiditis, *e g* from spinal anæsthesia**

The main interest in this area is spinal tumour and *prolapsed intervertebral disc* The previous view was that a prolapsed disc usually produced a central space-filling lesion and this caused symptoms and signs similar to a spinal tumour Stookey (1940) pointed out that a prolapsed intervertebral disc might be present in one of three ways (1) with bilateral ventral pressure, (2) with unilateral ventral pressure, or (3) with pure root pressure this author advised surgical exploration where such a cause was suspected Recently several workers have described lateral protusions giving rise to brachial neuralgia (Seemes and Murphy, 1943, Spurling and Scoville, 1944, Elliot and Kremer, 1945) In eighteen cases operation has been necessary and in all the suspected disc has been removed with, except in one long-standing case, complete relief to the patient The original paper of Seemes and Murphy was particularly interesting as this series of four cases included two physicians and in all cases the onset was sudden, with precordial pain radiating down the arm All victims considered themselves to have had heart attacks This initial precordial pain has not been recorded by other writers, but inevitably brings to mind the work of Lewis and Kellgren, and their artificial representation of anginal pain by the injection of the

recorded as of the fifth disc The points of greatest strain in the cervical spine are the fifth and sixth discs, and the fact that these cases have tended to appear in older persons who are still active suggests that degenerative change is the cause Though a high number of these cases show radiological evidence of degenerative change in the cervical spine, this evidence would appear to be double-edged as, in fact, the degenerative change of the case may be secondary to change in the disc

From a study of these papers there emerges a fairly characteristic clinical picture A history of trauma is not usual, cases of severe trauma appear to have a central prolapse leading to cord-compression symptoms more frequently then a lateral prolapse The onset is usually with a severe pain in the neck region The pain then spreads at a variable speed, often taking days, to involve the back of the shoulder and the radial side of the arm Sometimes the pain is lancinating in type but dull and boring is a more usual description.

Intensification of the pain by coughing or sneezing is frequent. *Paræsthesiæ and* numbness appear later, in the case of the fifth disc *they terminate* in the posterior aspect of the thumb, but in the case *of the sixth* disc the distribution is wider, the index, middle and *occasionally the* ring finger are involved

The diagnosis is helped by the fact that the *syndrome is primarily* uniradicular, this is a consequence of the anatomy of the part, *the* involved root only traversing a very short path *to pass out of the* intervertebral foramen Cervical nerve roots run at right angles to the spinal cord, and each root overlies a *single intervertebral* disc Thus a cervical prolapsed disc can involve only one nerve, an important distinction from the case in the lumbar region

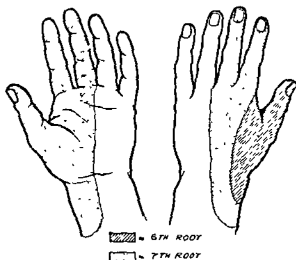


FIG 224

Diagram showing areas of disturbed sensation in lesions of the sixth and seventh cervical roots

Examination reveals several important features. Firstly, the production of pain by bending the neck to the side of the lesion, with pressure on the forehead, is regarded by Spurling and Scoville as practically pathognomonic if present. Elliot and Kremer did not completely confirm the finding, but reported that in their cases there was nearly always one position of the neck that caused pain; they stressed the fact that a single position must be tested for some time as the pain response showed a lag. Percussion over the affected vertebræ gave a positive result of radiating pain in several of Spurling's cases.

The findings in the limbs are of great importance. If the fifth disc is at fault the biceps reflex will be lessened, whilst the triceps reflex is normal, with the sixth disc at fault the triceps will be weak,

Neurological signs are difficult to elicit, but important in the diagnosis The fifth disc gives a small area of hypoalgesia and hypoæsthesia largely confined to the base and posterior portion of the thumb, whilst the sixth disc syndrome embraces a wider area usually including the middle as well as the index finger A point of great tenderness is often present at the base of the neck

Spurling and Scoville make the interesting point that a major or minor scalenus anterior syndrome may be superadded from irritation of the root The nerve supply of the scalenus anterior is given variously as either 4, 5 and 6 cervical roots or the lower 4 or 5 cervical roots

Elliot and Kremer mention the presence of "trigger areas" in those muscles which are tender Infiltration with procaine will relieve the patient's symptoms, this caused an initial diagnosis of fibrositis to be made in some of their cases

X-ray changes if present comprise a reduction in the normal cervical lordosis, a narrowing of the fifth or sixth cervical with sclerosis of the adjacent intervertebral space margins Spurling illustrates a marked narrowing of the intervertebral foramen These changes are only suggestive, as they may appear in normal persons

Contrast myelography with pantopaque was positive in ten of eleven cases verified by operation in Spurling and Scoville's series.

Diagnosis

The essential diagnostic feature of this lesion is its uniradicular distribution (either C_6 or C_7) As would be expected, muscle-wasting and motor weakness are not usually found, as only a single root is affected With care the characteristic area of diminished sensation [illegible]

dominant reference to C_8 and T_1 radicles, and often a vascular component Costoclavicular compression exhibits a rather similar picture but evidence of subclavian vein compression, if carefully sought for, will prove of use in differential diagnosis

If signs of both a prolapsed disc and a scalenus syndrome are present in the same patient, then the causative lesion is a prolapsed disc as C_6 and C_7 are rarely involved in the pure scalenus syndrome

Neuritis will usually exhibit signs of a widespread disorder with preferential attack of certain roots Paralysis or marked weakness of a proximal limb muscle will make the diagnosis clear

Treatment

Seemes and Murphy operated on two out of four cases but in these the pain had been very severe for years

Spurling and Scoville's paper dealt only with operated cases, whilst Elliot and Kremer did not operate on any of their eight cases

The prognosis of the unoperated case is of very great interest as it will largely determine treatment Old case notes (Fletcher, E.)

revealed nineteen cases whose brachial neuralgia was possibly due to prolapsed disc. The results and duration of treatment are given below Turner (1945) stated that he had in the past eighteen months twenty such cases Acute pain radiating down the arm stopped within five weeks in sixteen cases and within six weeks in one case. Two cases had pain of decreasing severity after five weeks, when they were transferred to other hospitals One case was discharged from the service after nine weeks with severe pain

Duration of Treatment	2 *weeks*	4 *weeks*	6 *weeks*	8 *weeks*	12 *weeks*	16 *weeks*	1 *year*	2 *years*	
S F	1	1	2		2	1	1		8
I		2		2				1	5
N I			1	1	3		1		6

This incomplete data suggests that the prognosis is good and that operation will not be frequently necessary.

Rest in bed with the head supported with pillows in the position of greatest comfort, or with light head suspension, if this gives relief, will be required in the severe cases, whilst analgesics will be required in practically all cases There is insufficient data to decide when operation should be considered, but if the symptoms are still severe after five to six weeks of conservative therapy, then this method of attack may be required

The chief differential diagnosis will be from tumour, in fact the protrusion is a particular form of tumour The chief diagnostic points will be the absence of root symptoms in other parts of the body and the fact that the cord itself does not show evidence of pressure as evinced by spastic paralysis of the trunk and lower limbs, together with increased reflexes and extensor plantar responses X-ray evidence and lumbar puncture may aid in the differentiation, as may pantopaque myelography

III. CAUSES IN VERTEBRAL COLUMN

1. **Neoplasm** *
2. **Paget's Disease**
3. **Trauma (late and early effects)** *
4. **Ankylosing Spondylitis** *
5. **Cervical Caries** *
6. **Osteoarthritis of Spine**

Causes in the vertebral column are quite frequently a source of pain. X-ray will help considerably in their differentiation. It is a notable peculiarity of osteoarthritis of the spine that though it is often responsible for pain leading to the deltoid, the pain almost always stops at the insertion of the muscle Spinal caries in children is often a trap for the unwary, as pain may be complained of before radiological evidence of the disability is present.

IV. CAUSES AROUND RIBS AND CLAVICLE

1. Cervical Rib *
2. Abnormalities of First Thoracic Rib *
3. Abnormal Thoracic Outlet *
4. Costoclavicular Compression *
5. Scalenus Anterior Syndrome *
6. Aneurysm of Subclavian Artery (resulting from one of the above and producing pressure symptoms)
7. Compression over a Normal First Thoracic Rib

(1–7: With or without abnormalities of brachial plexus, e g pre- or post-fixed)

Recently a considerable amount of work has been performed to demonstrate the importance of constriction in the region of the first rib in producing symptoms referred down the arm

Cervical rib and the *scalenus syndrome* have been known for many years, but recent work, whilst emphasising the importance of this region in symptom production, has modified conceptions of the anatomical factors involved.

The symptoms developing in the arm differ according to which abnormality is present If either a cervical rib or the scalenus anterior syndrome is present, then either the subclavian artery or the lower trunk of the brachial plexus may be compressed If compression between the clavicle and first rib occurs, then the subclavian vein bears the brunt, and the artery and nerve become compressed later

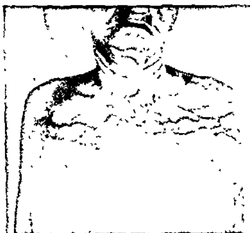


Fig 225

The superficial collateral circulation which does not pass through the subclavian vein

Infra red photograph

(By courtesy of the *American Heart Journal*)

The syndrome of *costoclavicular compression* is a relatively new concept Eden (1939) was the first to bring it forward in order to explain the curious finding of an aneurysm of the subclavian artery *distal* to cervical ribs. Eckhoff (1941) quotes Symonds, who saw a case of cerebral embolism which resulted from spreading thrombosis in the subclavian artery secondary to this condition An excellent paper by Sampson Sanders and Capps (1940) showed that in fact costoclavicular compression of the subclavian vein could be produced in many apparently normal persons by bracing back the shoulders.

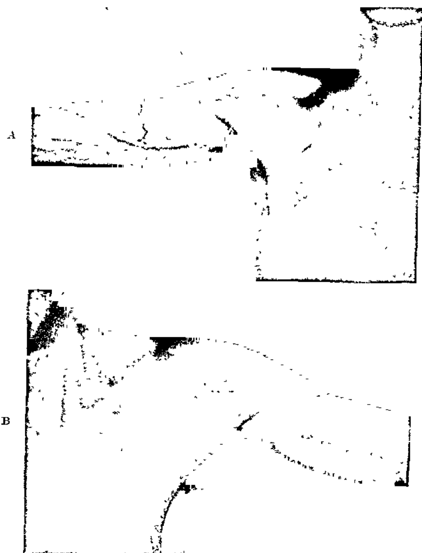


FIG 226

These two pictures are taken with infra red film to demonstrate the collateral circulation over the chest and arm when pressure occurs between the clavicle and the first rib In A this is well demonstrated B shows a case in which the first rib has been removed as part of a thorocoplasty performed for pulmonary tuberculosis It will be noticed that little evidence of collateral circulation is present and this has been found to be common, and is presumably due to the fact that the rib has been removed and the pressure on the subclavian vessels is not being exerted This is merely a presumption, as it is possible for pressure to be exerted on these vessels at other sites (see text)

These workers showed the importance of the superficial collatera circulation which does not pass through the subclavian vein. Th system provides for venous drainage when the subclavian vein is ob structed They showed that this syndrome occurred predominantly after forty years of age, and believed that this was due to either elevation of the ribs or their increased projection, in some cases caused by emphysema Further factors were the positions of the clavicle, especially its angle, the horizontal plane of the sterno-clavicular joint and back of the frontal plane of that joint. Though not demonstrated, it was thought that the subclavius muscle might play some part in the syndrome Thoracic scoliosis was an important factor in determining which side the symptoms appeared They even recorded tight brassiere straps causing indirect pressure via the trapezius This work is of obvious importance in explaining "idiopathic" thrombosis of the axillary vein

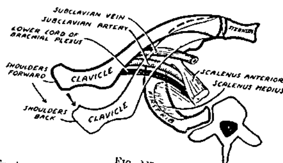


FIG 227

To show the relationship (in one plane) of the structures crossing the first rib, and the effect of bracing the shoulders

Lewis and Pickering (1934) recorded a case where thrombosis of the subclavian artery due to costoclavicular compression led to severe impairment of the hand circulation because of recurrent embolism This and other cases were used by Eden (1939) to demonstrate that direct vessel damage and not damage to the sympathetic nerve fibres was the essential lesion in the deficient arm circulation sometimes seen in these cases

The significance of costoclavicular compression of the subclavian artery has been advanced by Falconer and Wedell (1943), who showed in 50 normal men and 50 normal women that the radial pulse as affected in 25 of the men and 30 of the women on backward and ownward displacement of the shoulder or hyperextension of the eck, in 18 men and 19 women the radial pulse was obliterated by is manœuvre Wright (1945) investigated 150 young adults and und that with hyperabduction of the arms, the right pulse could be terrupted in 125 cases and the left in 128 cases In only 11 cases uld no obliteration be produced in either arm It is probable that this position the vessels are stretched where they pass between the toralis minor and the coracoid process. Wright recorded four

cases where neurological and vascular symptoms appeared to have been produced by the adoption of this attitude in bed

Nervous symptoms from costoclavicular compression seem to be less common than vascular symptoms This is understandable on the basis of the anatomy of the parts, the "jaws of the vice" initially affecting anteriorly placed structures.

A most interesting case of combined venous, arterial and nerve compression has been recorded by Le Vay. In this case symptoms became severe only after operation to divide the scalenus anterior; as this author points out, this muscle may provide partial protection of the artery and nerve in cases of costoclavicular compression. Falconer and Wedell's three cases were primarily vascular in symptomatology and these authors' operative observations conclusively demonstrated the severe nature of the constriction between the clavicle and first rib by actual measurement.

Walshe, Jackson, and Wyburn Mason (1944) included in their scholarly paper details of four cases in which vascular damage was the prominent feature, of particular interest were their arguments against the view that sympathetic stimulation at the region of the rib played any part in this syndrome Their introductory remarks sum up the position of the *cervical rib* with considerable precision: "It might almost be said that an abnormal first rib is never a solitary anatomical aberration and indeed it will be submitted in this paper that cases of abnormal rib asso
be primarily thought of, not in
present, but in terms of an ab..
outlet is invariably asymmetrical, commonly narrower on one side than the other, and tilted to one side This is the essential abnormality from a clinical point of view, and whether the abnormal rib in question is cervical or first thoracic is probably in most cases a matter of indifference."

White *et al* (1945), in a study of ten cases of congenital variations of the first rib, in whom five required operative treatment, make several important points Many cases previously diagnosed as suffering from cervical rib, in actual fact have possessed an abnormal first rib, the current radiological investigations being inadequate They point out the only certain means of deciding this matter is to X-ray the whole cervical spine, and that the obliteration of the atlas in the conventional view should be overcome by taking a long exposure and moving the mandible in order to blur its outlines. In difficult cases the entire spine may have to be X-rayed together with all the ribs

Clinical Features

The clinical features may present a mixed or a comparatively pure form of any of the three syndromes mentioned below.

(a) Venous Obstruction

Unless complicated by axillary thrombosis is unlikely to bring the patient to see medical advice As has already been mentioned,

channels, other than those liable to constriction, exist, and allow venous drainage of the arm even if the main channel is not patent.

(b) Arterial Manifestations may occur in three forms

(1) The common form in which the patient suffers from attacks, merging later into a more or less permanent state, of recurrent coldness of the arm and digits, with cyanosis, marked pallor, and sometimes Raynaud-like attacks.

(2) The syndrome of complete or partial occlusion of the artery with ischemia and pain in the limb, and occasional embolism of the digits leading to small areas of gangrene. The emboli come from the occluded subclavian, and are probably broken off as the result of exercise

(3) An uncommon form where a patent aneurysmal dilation of the subclavian artery (third part) exists with increased pulsation, a bruit, and possibly a thrill An aneurysm either patent or occluded may cause neurological symptoms, as was seen in one of Walshe's cases

(c) Nervous Manifestations

Kinnier Wilson (1940) has made considerable contributions to this subject

Symptoms may be divided into those of irritation, and those due to loss of function

(1) Sensory symptoms are usually prominent Pain and paræsthesiæ are referred to the hand and fingers The pain can often be elicited from above the region of the clavicle and is frequently described as shooting either into the ulnar or less frequently the radial distributions Positioning of the arm by bracing back the shoulders will often induce an attack

Objective sensory loss is very variable and often absent, it is not uniradicular, a rather characteristic distribution is along the ulnar border of the arm, at times it may be found in one or two of the fingers No particular form of sensibility is constantly affected

(2) Motor symptoms are often minimal, but Kinnier Wilson has pointed out that two types may occur firstly, involving the thenar eminence with local wasting affecting the two and a half muscles of the thenar eminence supplied by a twig of the median nerve, i e, abductor pollicis, opponens pollicis, and half of the flexor pollicis brevis, secondly, a general wasting of the interossei and an approximation to the main-en-griffe

Wilson explains the thenar wasting by stating that though the fibres involved [illegible]

C_7 and thus [illegible]

in relation to

the facts, and

elsewhere

Diagnosis

Faced with a patient presenting the above-described clinical picture, a diagnosis of the precise anatomical lesion responsible for the symptoms is at times difficult. The patient will often be in the older age-groups and frequently a woman, the present-day sex incidence is abnormal, owing to the unusual strains of Army existence A history of carrying heavy weights, or perhaps the dropping of the shoulders after childbirth, may be responsible. The old aphorism "a widow of forty, who takes in washing" is apt. In the early stages relief is obtained when the external factor is removed, but later the symptoms become almost continuous

Radiology will be of great assistance, but even if abnormalities of the ribs are noted, it must be remembered that such abnormalities are more often asymptomatic than not Posture tests are of considerable assistance, but, as many normal persons show a positive result, care must be taken in their interpretation. A posture test, i.e , hyperextension of the neck or bracing back of the shoulders, is only to be regarded as positive when the result is induced by such little force that it is likely to have been frequently experienced by the patient

The palpation of a lump in the neck with a strongly pulsating subclavian artery should be treated with reserve, as many normal persons may show such finding If venous engorgement of the superficial collateral circulation is easily produced, confirmed by direct venous pressure readings in the two positions, this is a pointer in favour of costoclavicular compression

Paralysing the scalenus anterior is of great utility as a clinical test to see whether this muscle is playing a part in the production of symptoms. The patient is placed in the recumbent position with the head turned toward the unaffected side. The scalenus anterior muscle is palpated behind the sternomastoid muscle. The lower portion of the muscle is then infiltrated with 10 c c of 1 per cent. procaine. Within ten minutes the scalenus will be completely relaxed—this manœuvre imitates surgical division

In many cases the precise diagnosis may have to wait on operative findings, if such a procedure is decided upon. White *et al.* (1945) have stressed the importance of removing an adequate amount of rib, as in two of their cases a second operation had to be performed for removal of the posterior stump of previous inadequate resections Conservative treatment in the milder cases may prove successful. Prohibition of the activities responsible for the symptoms, together with orthopædic exercises to correct any deformities and to strengthen the muscles of the shoulder girdle, may be used

COMPRESSION OVER A NORMAL FIRST THORACIC RIB, THE SYNDROME OF ACROPARÆSTHESIA

The term acroparæsthesia is used to denote a condition, typically seen in middle-aged women, in which complaints are made of pain, numbness, or tingling sensations running down both arms, but in

which physical signs are usually lacking. Frequently a history of unusual long-continued exertion is given, or the recent assumption of some arduous occupation. Since the outbreak of war the con-
[illegible] ined to females.
[illegible] care of a child,

The onset is gradual, and at first occasional bouts of numbness, pain, a tingling sensation appear chiefly in the distribution of the ulnar nerve and often at the end of a hard day's work. The symptoms may be particularly prominent in the digits and lead to clumsy finger [illegible]

frequently measured in months, the symptoms reach a peak of disability and severity and tend to fluctuate around this level. A carefully taken history will frequently elicit the fact that any holiday has been followed by a marked remission of symptoms Occasionally the symptoms are complained of in one arm, but in the majority of cases both arms are involved by the time medical advice is sought

In some cases the tingling and numbness come on at night and if sufficiently severe may wake the patient

Examination may reveal little, but the absence of objective signs to explain subjective symptoms must not mislead the clinician The patient will give the impression of being fatigued, and in many this will be a presenting complaint. Often the *shoulders will be set noticeably low, the line of the clavicle being almost horizontal* This point, however, is not diagnostic, as some normal persons show similar findings No muscle wasting will be found nor is objective sensory loss usual Tenderness may be marked in the muscles of the forearm and also in the hand Cyanosis and pallor of the fingers occur at times Weakness of grasp may be suspected, but pain and tenderness interfere with the test

The ætiology of this condition has long been a matter of speculation, but Walshe (1945) in a forceful article has re-emphasised the importance of the topographical relationship of the shoulder girdle to the upper thoracic outlet This worker points out that the striking complaint of these patients is of fatigue and debility, with a history of heavy use of the arms and great relief of symptoms after holidays His belief, supported by convincing reasoning, is that in the great majority of these cases the shoulder girdle has dropped in relation to a normal upper thoracic outlet, and thus causes tension on components of the brachial plexus as they pass over a normal first thoracic rib. This contention is supported by the fact that the syndrome tends to occur later in life, when it is a well-known fact that this dropping of the shoulder girdle is extremely common.

TREATMENT

If the above-mentioned ætiological view is accepted, then it will be apparent that the symptoms will be relieved only by measures that

alter the relationship of the shoulder girdle to the thoracic outlet. The simplest method of procuring this result is by means of a *period of rest in bed* with both arms supported by slings. This apparently drastic treatment is effective in a short time and is often the only means by which relief can be obtained. One week is often a sufficient period for the relief of acute symptoms. After the period of rest, heavy work must be limited to that amount which the patient can perform without symptoms General measures to improve the health, such as the correction of anæmia, together with orthopædic exercises to improve the tone of the shoulder muscles will be of assistance in increasing the amount of work that can be performed.

V. CAUSES IN OTHER REGIONS

1. Superior Sulcus Pulmonary Tumour
2. Other Tumours
3. Fractures

Superior sulcus pulmonary tumours sometimes present with pain down the arm. Fractures may involve nerves directly or in reactionary tissue formation Rarely other tumours may cause brachial neuralgia, these will nearly always be obvious

VI. CAUSES WITHIN THE NERVES

1. Herpes Zoster
2. Tumour of Nerve (neurofibromata)
3. Neuritis: (a) idiopathic (? virus causation)
(b) diabetes, Vitamin B_1 deficiency, etc.

Herpes Zoster eruption is characteristically preceded by severe pain, the appearance of the eruption renders the diagnosis easy. Especially in older persons, post-herpetic neuralgia is frequent, and at times severe X-ray treatment may be curative.

The rare neurofibromata of nerve often causes a shooting pain to the extremity. Diagnosis is often difficult as the tumour may be very small. Excision is the only satisfactory proceeding.

Neuritis

Several authors have remarked on the greatly increased incidence of "idiopathic" neuritis seen during the war years (references given previously) Such causes as trauma, intoxications, or deficiency states have been eliminated in these series, and it is believed without much evidence that the conditions may be the result of a virus infection

Wyburn-Mason in his description of 42 cases pointed out that the changes were widespread, the anterior rami from C_3 to D_4 being affected, with preferential attack in the C_{5-6} segments, both sensory and deep branches The clinical features of this "epidemic" comprised initial burning pain in the region of the shoulder, which travelled down the arm; in some cases pain began in other situations and later became general. In most cases motor weakness was widespread,

but in some it was confined to one or two muscles. The tendon reflexes tended to be increased in the earlier cases, and decreased in the later cases.

Spillane (1943) reported a rather different type of clinical picture with localised "neuritis of the shoulder" In his cases acute pain in the shoulder was present for 3–14 days Paralysis or wasting then occurred, pain disappearing at the end of 6–7 weeks Dixon and Dick (1945), reporting on the end result of this type of epidemic, showed that little improvement occurred for two months, but at the end of six months considerable improvement had been made. In their experience second attacks were very common· out of sixteen cases, five developed recurrences, or had spread to the other side.

Turner's paper (1944) dealt with 36 cases and showed a clinical picture midway between these last two authors In his case, severe pain developed across the back of the shoulder, which radiated down the outer side of the arm and sometimes to the upper part of the chest. The pain remained severe for some days, followed by weakness of the shoulder As the paralysis appeared, the severe pain was replaced by a dull ache, the paralysis persisting.

Certain of these cases mimic anterior poliomyelitis, as on occasion the onset is febrile with sudden paralysis of muscle or muscles, with little radiating pain In fact, one personal case was so diagnosed before these papers had been published Spillane believed that anterior poliomyelitis might be excluded as—

(*a*) no general signs of infection were seen,
(*b*) examination of the cerebrospinal fluid was negative,
(*c*) diffuse hyperæsthesia was not an essential part of the syndrome;
(*d*) the peripheral character of the shoulder lesions

The undoubted existence of this "idiopathic" type of neuritis does not absolve the practitioner from excluding the common causes of polyneuritis, diabetes, lead, etc It is probable that the mild cases of brachial neuritis sometimes seen in pregnancy have their origin in B_1 deficiency, as requirements of B_1 in pregnancy are some three times that normally required

Diagnosis

The diagnosis of this complaint rests partly on the exclusion of the other lesions described in this chapter. Positive features leading to the diagnosis of a neuritis are—

(1) Evidence of many roots being affected
(2) Pronounced motor weakness
(3) General increase or diminution of all the reflexes in the affected limb
(4) Discovery of some cause, e.g. previous injection of serum, history of poisoning, the presence of diabetes, etc
(5) The paralysis of proximal limb muscles or muscle

The Treatment of brachial neuritis is conservative and symptomatic Splinting with an abduction splint in the acute stage, to

prevent contractures, and graded physiotherapy in the later stages. Analgesic drugs will be required in most cases, and bed rest is sometimes necessary. It is probably advisable to give a few injections of vitamin B_1 so that recovery will not be retarded by the lack of this substance.

VII. REFERRED PAIN

1. Myalgia
2. Disease of Shoulder
3. Angina
4. Thoracic Tumours
5. Apical Pleurisy

Referred pain is frequent in the arm from such causes as myalgia and diseases of the shoulder joint (dealt with elsewhere); on occasions apical pleurisy, the well-known anginal pains, and those of thoracic tumours may cause confusion.

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CHAPTER XXXI

THE SHOULDER JOINT

THE section on the shoulder joint in the chapter on Applied Anatomy should be studied before this chapter is read.

For purposes of description and ease of arrangement it is proposed to deal with disorders of the shoulder joint under two headings *Uncommon causes* of shoulder symptoms will be dealt with first and then the *common ones* will be described.

Before dealing with ætiology it is necessary to emphasise that the shoulder joint is only part of what some now call the "*arm-trunk*" *mechanism* The other joints which enter into this arrangement are, the acromiohumeral joint, the thoracoscapular joint, the acromioclavicular joint, the sternoclavicular joint and the biceps tendon sheath mechanism All these "joints" move synchronously and synergically in the purposive movements of the arm and shoulder

Lockhart (1930) expressed himself very concisely on this point. He said that in raising the arm from the side to the vertical there was continuous correlated movement in all these joints, and continuous activity of all the associated muscles The old teaching was that abduction to the right angle was secured by the deltoid and that further movement was due to the rotation of the scapula by the trapezius and serratus, the angle between the scapula and the humerus remaining the same

Some point has been made of this change of opinion, as it is concerned in the identification of lesions of the shoulder joint and its surrounding structures

Moseley (1945) has made some observations on shoulder movement In cases of "periarthritis" of the shoulder all movement at the glenohumeral and acromiohumeral joints is prevented, but it is well known that the arm can be elevated from the side because of the scapular movement round the body which allows elevation forwards of the coronal plane In a case of ankylosing spondylitis the *scapula was firmly fixed to the chest wall*, but the glenohumeral and acromiohumeral joints were free In this case there was full rotation of the humerus in adduction which diminished rapidly as the arm came to the full limit of abduction, 90° The arm could be brought forward 20° and backwards 10° from the coronal plane in abduction at 90°. If the acromioclavicular joint is ankylosed, little interference with movement is noticed, but if *injured and painful* the arm cannot be abducted above the horizontal nor adducted across the body

of

tal

Overlapping and compensation will account for the small place allotted to these accessory joints in the final analysis.

The Action of Certain Muscles and the Effects produced when they are Paralysed

Moseley has described the effect of paralysis of certain muscles.

Paralysis of the trapezius.—The scapular level is apparently determined by the levator anguli scapulæ, and in paralysis of the trapezius the superior angle may rest even higher than is usual. Usually there is instability of the scapula when the arm is above the horizontal. Moseley states that removal of the rhomboids with the trapezius below the level of C_7 leads to no permanent loss of power.

Paralysis of the deltoid.—In this case the power of abduction is still left up to 30°. This is due to the action of the supraspinatus and the "shrugging" mechanism. In one case complete compensation has been described, the supraspinatus and other muscles taking over the complete abduction movement when permanent paralysis of the deltoid has been present, this is somewhat unusual.

Paralysis of the serratus magnus.—Winging of the scapula may occur either at rest or with the arms pressing against a wall. The reason for the winging at rest is that the weight of the arm pushes the scapula toward the mid-line.

Rupture of the supraspinatus muscle.—It has been found in cases where this lesion exists that injection of procaine leads to recovery of function. From this it is deduced that this muscle is not essential in the production of the first 30° of abduction (cf. paralysis of deltoid). Its essential action appears to be abduction *against resistance.*

Rotator cuff.—This consists principally of the infraspinatus, teres minor and subscapularis muscles and they act as a "sling" for the head of the humerus. It is thought that the supraspinatus and the long tendon of the biceps act as a fulcrum superiorly and allow the head of the humerus to descend gently in the glenoid fossa as the arm is abducted. It seems fairly clear from experiments which have been made that the long tendon of the biceps has no other important function.

EXAMINATION OF THE SHOULDER

Before making any manual examination it is well to look at the patient carefully. The following points are useful:

Looking at the patient from the front—note the set of the head, whether straight or deviated, the level and height of the shoulders and the development of the deltoids, the tension of the pectoralis; the length of the arms, the crease of the axilla; wasting of muscles and fibrillation.

Looking at the patient from behind—note any deviation of the spine; whether one scapula is nearer the mid-line than the other; the development of the muscles; if the shoulders droop, which droops most, atrophy of muscles; the length of the neck and the "set" of the head on the shoulders.

Looking from the side—note kyphosis, drooping shoulders and neck flexion.

Passive Movement of the Arm

With one hand covering the shoulder joint and part of the [illegible] gently rotate the humerus [illegible] freedom. Continuing the [illegible] the side until no further movement can be obtained and note the height at which this occurs, and the point at which the scapula commences to move. Compare with the other side

Active Movement of the Arm

Note the degree of movement obtained (*a*) in flexion, (*b*) in abduction, (*c*) in circumabduction, i e with the arm behind the back. Ask the patient to reach as high behind the back as possible In a normal patient of 30 years of age the index finger should reach within five inches of the seventh cervical vertebra with either arm. *Palpate* the muscles round the shoulder joint and include the muscles of the rotator cuff, trapezius, and the adductors, especially the latissimus and teres major

UNCOMMON CAUSES OF SHOULDER PAIN

Referred pain from inflammation and new growth in the spine or bones, peripheral vascular disorders; cardiac lesions, especially angina pectoris and coronary disease, superior sulcus pulmonary tumours, cholecystitis, involvement of the diaphragm and certain gastric conditions, lower motor neurone disease, peripheral neuritis, herniation of a nucleus pulposus.

In the majority of cases the diagnosis will be clear on careful examination, and mostly will depend on further physical signs The remainder will be decided by X-ray Herniation of a nucleus pulposus is discussed in the chapter on Brachial Neuralgia

A number of conditions remain which are not at all clear on general medical examination, but which can be elucidated by examination of the locomotor system, and these comprise the common causes of shoulder pain

COMMON CAUSES OF SHOULDER PAIN

Cervical rib and scalenus anterior syndromes, osteoarthritis of the cervical spine and ankylosing spondylitis, lesions of the rotator cuff, Duplay's syndrome which includes subacromial bursitis and chronic adhesive capsulitis, arthritis of the shoulder joint, the sterno-clavicular and acromioclavicular joints, bicipital tendon lesions, fibrositis of the deltoid, supraspinatus, infraspinatus, or rhomboids.

The cervical rib and scalenus anterior syndromes are dealt with in the chapter on Brachial Neuralgia Osteoarthritis of the spine and ankylosing spondylitis have their own chapters

Lesions of the rotator cuff are nearly all traumatic They generally

occur in the fifth or sixth decade. Males are more frequently affected than females, and the *right shoulder more often than the left.* Meyer (1937) examined post-mortem material from cases of an average age of sixty years. He considered the lesions which he found to be due to everyday use and not to extraordinary or forceful action. *Common post-mortem lesions at average age sixty.* He found fraying and erosion of various structures, including the subdeltoid bursa, the articular capsule, certain ligaments including the coracohumeral ligament, the tendon of the supraspinatus and the long tendon of the biceps The acromioclavicular and humeroscapular joints showed *thinning and destruction of their articular cartilages, and eburnation.* In some bodies he found a true coracoclavicular joint, and "polishing" of the coracoid process from contact with the head and tuberosities of the humerus Degeneration and fraying were seen in many bursæ, and Meyer considered that these were not due to a bursitis but to a long-continued movement. It is evident that there are very good reasons for shoulder lesions to occur more commonly in the elderly.

Philip Wilson (1939) analysed 168 cases of shoulder pain (not all shoulder lesions) *He found 89 cases of what he called lesions of the* subacromial bursa, which included calcifying tendinitis, periarticular adhesions and rupture of the supraspinatus tendon and other tendons. In this same series five cases of rheumatoid arthritis of the shoulder joint appeared and two cases of osteoarthritis of the acromioclavicular joint. Wilson felt that the differentiation of shoulder lesions on the basis that they did or did not involve the subacromial bursa was not entirely desirable. He would have preferred to use a pathological classification and with this view many would agree Unfortunately *the exact pathology of many shoulder conditions is not known.* With this point in mind it seemed likely that these lesions as a whole could be understood more easily if considered in relation to the subacromial bursa. This group of 89 cases included 17 of undifferentiated traumatic origin Even if these traumatic cases are excluded, the group still comprises the great bulk of shoulder problems Twenty-five cases of calcifying tendinitis, thirty-six cases of periarticular adhesions, and eleven cases of rupture of the supraspinatus and other tendons were found within the group.

With regard to calcifying tendinitis, although any tendon may be *involved, the* lesion usually occurs in the tendon of the supraspinatus close to its insertion It is thought that the deposit of calcium [illegible] of the tendon [illegible] is [illegible] al bursa, with its rich supply of vessels and nerves, becomes involved. This process of calcification has been likened to that which sometimes occurs in the extensor longus pollicis, or (with less likelihood) to the calcification of the middle arterial coat in Monckeberg's sclerosis Codman (1934), the great American surgeon, was of opinion that to describe bursitis as an entity was equivalent to describing peritonitis as an entity. He said that the subacromial

bursa was not a structure where disease starts, "so much as a structure which limits disease in the adjacent structures . . by causing fixation of the parts "

It is clear then that we have a great group of cases which may be due either to a primary tendinitis leading to subacromial bursitis, or to adhesions secondary to injury or metabolic causes This forms the largest group of cases, but a smaller group is due to calcifying tendinitis associated with calcareous deposits and also associated with subacromial bursitis

These lesions may be associated with trauma (uncommonly), gout, diabetes, or fibrositis Occasionally they are found in cases of hemiplegia

The *pain* is usually felt diffusely over the shoulder, anteriorly over the long head and belly of the biceps, or over the scapula

The *cardinal sign* is limitation of movement which gradually increases as time goes on *Muscular wasting* is variable but is nearly always present to a slight degree It may be due to disuse and principally affects the deltoid, supraspinatus and infraspinatus *Tender points* are also variable, they may be found over the acromion process, the coracoid process, insertion of the deltoid or long head of the biceps Wilson tried to determine where the actual lesion was situate in cases of periarticular adhesions At open operation he placed a finger in the subacromial bursa and manipulated the shoulder He felt the adhesions give under his finger, which was naturally resting on the capsule He also felt some snap anteriorly in the region of the subscapularis tendon It seems possible that a tendinitis is not a necessary prerequisite for the production of the syndrome It may be that the lesion is really a low-grade "capsulitis" and that the folds of the capsule become adherent and so limit the movement of the joint

In one personal case the electrode of an electromyogram was placed in the capsule of the shoulder joint and the joint manipulated No camera was attached to the instrument so a visual record is not available, but the noises which emanated from the loud-speaker seemed to indicate that the electrode rested very near a part where violent reaction was taking place The general course of the trouble suggests (as Wilson thought) that the lesion in many cases may be in the joint capsule

To sum up, the present position is that four classes of case may comprise the syndrome generically known as "periarthritis of the shoulder," Duplay's syndrome, or subacromial (subdeltoid) bursitis As Duplay's syndrome is a term which conveys no belief in any particular pathology, it seems most suited for the purpose

Duplay's Syndrome

1 *Primary tendinitis* (generally supraspinatus), associated with subacromial bursitis

2. *Calcifying tendinitis* with calcareous deposits, and a subacromial bursitis

3. *Periarticular adhesions.*
4. *An "adhesive" capsulitis* (? adhesive bursitis).

Important Points in the Diagnosis of these Lesions

1. Some cases are met with in which *abduction* cannot be carried out *through the first* 30° without help, and on the return movement control is lost through the same range. They are found *in middle-aged* men, are closely associated with injury, and the lesion is rupture of



Fig. 228

Calcifying tendinitis with calcareous deposits

the supraspinatus tendon. *They should be referred to an orthopædic surgeon without delay.*

2. In some cases a very sharp twinge of pain is felt as the *greater tuberosity passes under the acromion.* This sign indicates that a bursitis is present, and it may be secondary to the conditions already mentioned. This sign is a help in separating out the cases of adhesive capsulitis where the glenohumeral and acromiohumeral joints show practically no movement, and there is *no pain at rest.*

3. *Marked atrophy of muscles* is most often seen in the case of adhesive capsulitis, but it is as well to remember that motor neurone disease may start at the same site.

Treatment

Trigger points may be found either in the trapezius, supraspinatus, levator anguli scapulæ, or infraspinatus muscles These "points" are apt to be missed, especially when they are situate in the infraspinatus muscle, and must be searched for diligently If found they should be injected with procaine. Care must be taken that the solution goes accurately into the point of tenderness or the treatment will be ineffective



FIG 229
Showing wasting of the deltoid and pectoral muscles in a case of chronic adhesive capsulitis

A great many cases will be encountered in which so far as can be told periarticular adhesions or an adhesive capsulitis are present It has already been noticed that in Wilson's series this represented the largest group and in actual practice the same point will arise For these cases *manipulation under anæsthesia* is the treatment of choice When undertaking such a manœuvre it is wise to try to immobilise the scapula with a wide belt fastened fairly tightly round the chest This makes the subsequent manipulation easier to control In severe cases associated with much pain and limitation of movement it is as well to try to restore one movement at a time using a series of manipulations to obtain the final result Flexion and abduction

are the first movements to be restored, and the last and unfortunately generally the most difficult, is internal rotation.

Some authorities recommend immobilisation of the arm by bandaging it to the chest with the idea of relieving pain In my experience this is a mistake for it has two disadvantages, the amount of movement in the shoulder joint is further limited and the muscles atrophy to an even greater degree. In some cases atrophy occurs in the rotator cuff and in these cases particularly it is unwise to try to *do too much at a time.*

Cases

of the b

Movemen

Cases associated ... 'njection of

the capsule of the ... lf-per-cent.

novocaine with 1/20 ... has taken

effect the shoulder should be put through a full range of movement with the scapula fixed, and then with the scapula free. If this is ineffective the calcareous de

needling of the l

Irrigation of

In 1937, Patterson and Darrach described this method of irrigation The skin of the shoulder is sterilised and covered with sterile towels. The patient lies on his face, and two points are selected for the insertion of the two needles The *first* is somewhat loosely described as at the point of maximum tenderness Actually it is about one inch lateral to the coracoid process. This point is marked with a procaine wheal. The *second* is just behind the upper part of the greater tuberosity of the humerus This is marked in the same way. The skin over the first point is nicked with a scalpel and the needle is pushed through toward the under surface of the acromion process. The other needle is pushed through the second point about a fingerbreadth below the acromioclavicular joint towards the humerus, and both needles should lie in the bursa, which is now washed out with sterile saline. Good results sometimes follow this treatment, but if the case is of long standing, and the calcification has become ossified, it is contra-indicated.

In this case *operative removal* of the deposit may have to be considered *Deep X-ray therapy* is also sometimes used.

For some reason strapping the shoulder with elastoplast sometimes relieves the pain

Physical Therapy

The treatment of choice seems to be *radiant heat, massage and movements* to the neck and shoulder. Usually this is given three times a week for six weeks If no improvement has taken place at the end of that time the treatment is stopped.

Anodal galvanism with a large pad over the shoulder joint sometimes relieves the pain in cases of acute bursitis.

Diathermy has been recommended by some authors, but on the whole does little good.

Exercises are certainly useful. Swinging the arms in a stooped position with the muscles relaxed is one of the most useful, another is gradually "climbing up" a wall with the fingers and trying each day to get a little higher. The exercises may be begun in Guthrie slings with advantage.

Arthritis of the Joints of the Shoulder Girdle

There is no doubt that arthritis is uncommon. In advanced cases of rheumatoid arthritis the shoulder joint may be affected or even ankylosed, and the same thing may occur in cases of ankylosing spondylitis *Osteoarthritis* affects principally the acromioclavicular joint, but occasionally the shoulder joint itself is involved. On very rare occasions the *sternoclavicular joint* may be the first and for a long time the only joint involved in rheumatoid arthritis It is usually associated with an effusion Also on rare occasions a coraco-clavicular joint may be present and may confuse the issue

Bicipital Lesions

Moseley (1945) describes certain syndromes due to a tendinitis, tenosynovitis, or actual rupture of the biceps tendon

The *symptoms* are pain in the anterolateral aspect of the shoulder, with muscular spasm and pain in the trapezius, scalenes, deltoid and arm muscles There is also *stiffness* and *limitation of movement* in the shoulder joint Duplay's syndrome does not supervene. Tenderness is found over the bicipital groove and the following tests are used

1. *Faradic test* —Contraction is caused in the short head by an appropriate faradic current. This is not uncomfortable. The same stimulus is applied to the long head and pain is referred to the bicipital groove

2 *The tension test* —Locate the tendon above the muscle belly, and draw it from side to side, pain is again felt in the groove.

3 *Yergason's sign* —The elbow is flexed to 90° and the forearm supinated against resistance Pain will be felt in the bicipital groove in cases of tendinitis

4 With the arm in the anatomical position forced external

..

and reference should be made to the original work.

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CHAPTER XXXII

BACKACHE AND THE SPINE

THE causes of backache are so numerous that it would be extremely difficult to enumerate them all It is important, however, to separate those forms of backache due to disorders of the locomotor system from those arising from the cerebrospinal system and the body cavities Such a division has been attempted in this chapter The section which deals with locomotor disorders has been dealt with, as in other chapters, on a regional anatomical basis Some stress has been laid on the commoner causes of backache, as these are, generally speaking, the more difficult to deal with.

THE EVOLUTION OF THE SPINE AND SPINAL ANOMALIES

Some understanding of the more common anomalies of the spine is essential to the study of locomotor disorders In the absence of this, symptoms are constantly being attributed to X-ray and clinical findings which do not carry the significance allotted to them. In some of the advanced cases it cannot be denied that symptoms may be due to congenital abnormalities alone, but in the usual run no more than a predisposing rôle can be attributed to them. *In this section the* plan advocated by Steindler (1929), and originally set out by Putti, has been followed



Fig 230

This is an example of partial block vertebræ It will be noticed that there is a spinous process to each vertebra, but the two vertebræ are fused, and that there is no posterior spinal articulation Although this does not represent the full description of Klippel and Feil it is a potential cause of pain in the back of the neck

Morphological variations occur either in the anterior or posterior part of the vertebræ If the anterior part fails to develop either wedge-shaped vertebræ or independent body halves are found. If the posterior part is at fault the centres of the lateral portion of the neural arch fail to fuse, and a pseudo-articulation follows between pedicles and laminæ, as sometimes seen in spondylolisthesis *This failure to fuse leads to* a "giving way" at a spot which is only held together by fibrous tissue The defect in the laminæ between the superior and inferior articular processes is usually bilateral. The formation of hemivertebræ occurs both in the dorsal and lumbar spine and naturally architectural weakness follows.

An interesting aberration is the synostosis of vertebræ at different levels, for instance, the occurrence of block vertebræ in the neck,

which sometimes bears the names of Klippel and Feil (Fig. 230) Sometimes, but not always, this leads to a short neck Symptoms are often unjustifiably ascribed to this condition, perhaps because of the striking X-ray picture. *Certain symptoms*, however, are associated with the deformity Shortness of the neck, with the head right down on the thorax, occurs in severe cases Lateral bending and turning of the head are limited Feil added kyphoscoliosis as part of the syndrome and in some cases ataxia has been reported of the congenital or Friedreich type (Fig 230) A similar condition occurs in the lumbar spine



Fig 231
Complete fusion of the lumbar vertebræ associated with kyphosis

Spinal Evolution

In the *pronograde monkeys of the old world* the *twenty-seventh, twenty-eighth* and *twenty-ninth* vertebræ of the spinal series became modified to form the sacrum, and the lumbar spine formed *40–50 per cent* of the presacral spine. These monkeys, of course, progressed by jumping from their hind limbs, the thoracic cage being raised and extended by extension of the loins With a fixed pelvic base the lumbar spine acted as a *flexible lever* for moving the upper part of the body. In *orthograde apes* the *twenty-sixth* vertebra usually adopts sacral characteristics, thus reducing their lumbar vertebræ from the primitive number of seven to six Such apes like the gibbon, progress by means of their arms and the lumbar spine forms *24–29 per cent* of the presacral spine The spine has now become a *flexible lever* for attaching the pelvis and lower limbs to the body, and the weight does rest but only temporarily, on the lower limbs as the animal moves. So the evolution from pronograde to orthograde types was accompanied by a shortening of the lumbar spine, and Keith in his Hunterian Lectures has shown that this is accompanied by great saving in muscle energy

With the evolution of *plantigrade man* the lumbar spine became further modified At birth the lumbar spine measures 27 per cent of the presacral spine, the same as in the chimpanzee As the baby learns to walk however elongation takes place and in the adult it forms 32 per cent Watching a child commencing to walk brings reminiscences of the orthograde posture of the great anthropoid apes. With the growth of the lumbar vertebræ and the now completely upright posture the loins become lengthened and the lumbar curve develops In man the *twenty-fifth* vertebra usually forms the first of the sacral series

Because of these evolutionary traits the number of presacral vertebræ in man is still subject to variation. The change from pronograde to orthograde to plantigrade has left behind a somewhat fluid position, but the lengthening of the loins essential to graceful and efficient carriage makes it likely that *sacralisation* will be in a tailward direction (Fig. 232). Keith states that in 100 human skeletons, three or four will show headward sacralisation and six or eight a tailward movement. In a book of this type it hardly seems necessary or even desirable to go more deeply into this question, but



FIG 232

This patient had six lumbar vertebræ In this case the 26th presacral vertebra formed the first of the sacral series This represents the lengthening of the loins in man referred to in the text

Keith's great work is full of interest and even romance It should be added that these bony variations are naturally accompanied by their visceral components, such as the sacral and lumbar plexuses, which also move forwards or backwards, with, however, a considerable time-lag

Dorsal and cervical segments show some interchange. In man the last cervical vertebra more often shows dorsal characteristics, but the change may occur either way.

Spondylolisthesis

No doubt there is considerable variation in the angle of the sacrum to the lumbar and dorsal spine The straight loin of the negro may be compared with the almost horizontal position of the sacrum in some European women

The site of stress on the sacrum is at its anterior end and the coccygeal end would in the ordinary way tend to tilt up The

strength of the sacro-iliac and sacrotuberous ligaments prevents this. The resolution of forces so produced tends to force forward the lower end of the spine, so that it tends to become somewhat dislocated. Keith considers that a sudden muscular effort may snap the lamina of the last lumbar vertebra and so allow such a dislocation to occur. In this way the locking of the articular process of the fifth lumbar vertebra with that of the sacrum may become ineffective Keith's view is that no evidence exists for considering that the separation of the arch of the last lumbar vertebra is the result of congenital maldevelopment. Steindler considers, however, that special anatomic reasons (i e maldevelopment) must be present before such displacement can occur. Defects of the isthmic zone (the portion between the superior and inferior articular facets) are certainly commonly encountered but by no means always produce symptoms Repeated attempts to obtain definite proof of congenital defect in fœtal spines have been unsuccessful It seems that trauma (or repeated microtrauma) is the principal factor, but the anatomical lesion may predispose The clinical manifestations are considered separately.



Fig 233

This is a case of coxa vara It will be observed that the sacrum is almost horizontal There was no slipping of the 5th lumbar vertebra in this case in spite of the great deformity.

Scoliosis

Only in the case of man is the whole weight of the

to the fully established syndrome. Many authors differ in part from this theory and base some of their conclusions on the study of the groups of scolioses studied at birth.

Spina bifida occulta has as its pathological basis defective formation of the neural arches, more usually those of the fifth lumbar or first sacral vertebra.



Fig 234



Fig 235

Fig 234.—*Scoliosis* This X-ray shows the degenerative changes which occur at the point of maximum strain.

Fig 235.—*Scoliosis* To show in detail the changes described in Fig 234.

Spina bifida vera is associated with a hernial sac which makes a visible tumour under the skin This is not present in spina bifida occulta, but there may be signs of the underlying defect. These are usually hypertrichosis, or perhaps a tuft of hair, a dimple on the skin, a nævus, or a scar. Various pathological entities may be associated with the defect within the cord space. The importance of this anomaly varies greatly in different cases, but generally speaking, in patients who complain of no peripheral symptoms directly connected with the defect, its importance is not great, as it is usually found in routine X-rays taken for other purposes, and cannot be regarded as a direct cause of backache.

Anomalies of Articular and Transverse Processes

It is said that one-third of all spines show some type of congenital anomaly Many of these are of no clinical importance but anomalies [illegible] may produce symptoms

[illegible]

shown that the change of shape may be in the direction of shortening



Fig 236

Two congenital anomalies A mild case of *spina bifida occulta* with a transversosacral joint

and widening, leaving the articulation less stable. *Accessory facets* occur and the accessory joint between the transverse process of the fifth lumbar vertebra and the sacrum or ilium is discussed in the chapter on Sciatica

Comroe (1944) says that the facet planes are not purely saggital, coronal or oblique, but all carry some curved component The earliest clear evidence of some fault may be osteoarthritic changes seen in the X ray He also says that 25 per cent of lumbosacral joints show some asymmetry

Anomalies of transverse processes are common but not usually clinically important Many people fracture a transverse process without even knowing it has happened

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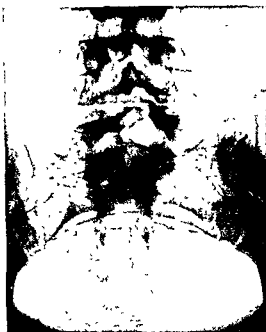


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BACKACHE DUE TO INFECTIVE DISEASES SUCH AS INFLUENZA, OR BRUCELLOSIS

This type of backache is usually a part of symptoms which are widely distributed all over the body The myalgias, arthralgias and



FIG 237

A good example of Schmorl's nodes Careful examination of the film will show a good many other minor deformities

other pains of many acute infective diseases are too widely known to need emphasis. They are specifically mentioned here because Copeman's recent work (see chapter on Fibrositis) seems to indicate that such pains, even though they may pass away at the end of the acute episode, are liable to return at a later date, because they have their basis in small muscular and fascial infiltrations which become asymptomatic but do not entirely resolve.

BACKACHE DUE TO SPECIFIC INVASION OF MUSCLE

Good examples of this type would be trichinosis, myositis due to typhoid fever, syphilis or scurvy, dermatomyositis.

The history and accompanying features generally make the diagnosis fairly clear Trichinosis may, however, present some difficulty, but the painful tender muscles, œdema of the face and the accompanying eosinophilia are helpful, even before the stage at which X-ray examination of the muscles becomes decisive

BACKACHE OF VISCERAL ORIGIN (USUALLY REFERRED PAIN)

(*a*) *From structures in the thorax*, such as the pain of pleurisy or following disease of any of the structures in the posterior mediastinum. *Secondarily* from such conditions as bone metastases from carcinoma of a bronchus.

(*b*) *From structures in the pelvis, especially from pregnancy, inflammation, new growth, or displacement of the pelvic organs*

(*c*) *From structures in the abdomen*, especially gastric and duodenal ulcers, renal conditions such as calculus, and pain referred to the left scapula in chronic pancreatitis Gall-bladder pain is occasionally predominantly to the back Some forms of backache are said to be due to constipation These are generally associated with visceroptosis or with some form of colitis Retroperitoneal neoplasms and such conditions as perinephric abscess may include backache as one of their presenting symptoms Abdominal aortic aneurysm produces severe pain in the back by direct pressure

(*d*) *From the central nervous system*, as in tabes dorsalis, polyomyelitis, epidemic encephalitis, spinal tumour, meningitis and disseminated sclerosis. Some neurological conditions produce pain in the back as a secondary phenomenon, e g the kyphosis of Friedreich's ataxia and the scoliosis of disseminated sclerosis. Syringomyelia, rather curiously, is a not uncommon cause of pain in the back of the neck

Certain of these conditions will not be referred to further as their position is self-evident As an example, bronchial carcinoma with secondary metastases evidently has no place except for the purpose of exclusion Certain pathological entities, however, play a very important part in the production of backache, and these will be referred to again.

A Discussion of Visceral Pain

Visceral pain in this sense can be defined as a pain produced by anatomical or physiological processes in the thoracic, abdominal, or pelvic cavities, which is "referred" to the back There may in addition be a type of pain in the extremities or the head with similar characteristics

The Pathway of Visceral Pain

It has been widely acknowledged since Sir James Mackenzie's day that symptoms of disease may be due to disturbed reflexes.

The pathway of such disturbing impulses as pain is generally thought to be through the posterior spinal roots, the efferent path being across the synapses to the anterior root. Such pain is felt in the thalamus through the lateral spinothalamic and other tracts. Section of the posterior roots occasionally fails to relieve pain in the appropriate area, so that two alternative pathways have been suggested, either by antidromic fibres in the anterior roots, or through the sympathetic system After thorough investigation it seems that whatever the nature of visceral pain the impulses enter the central nervous system via the posterior root. Although certain types of "receptors" in the skin have been differentiated, "receptors" in the viscera have not been determined. It has long been known that the viscera were not sensitive to various types of trauma, and although it now seems fairly clear that they are supplied with sensory nerves, it is still thought that the superficial and deep tenderness and muscular rigidity found in acute abdominal conditions are due to stimuli from the nerves of the parietal peritoneum. However this may be, Hurst pointed out in 1911 that the viscera were capable of being stimulated by producing tension within their walls. As has already been mentioned in the chapter on Sciatica, anæsthetisation of the area of skin to which pain is referred abolishes the pain. This has been taken to be further evidence in favour of Mackenzie's viscerosensory reflex, but several other theories also claim support. As an example, one alternative theory states that the afferent stimulus from the viscera causes a vascular reflex *in the skin*. This reflex excites the sensory nerve endings, and the impulses from them pass via the cerebrospinal nerves and posterior roots.

Back pain may be either deep or superficial. Davis (1940) suggests that when the pain is deep, the afferent impulses from the viscus stimulate efferent nerves to arteries and arterioles in the skeletal muscles of the same segment The changes so produced stimulate the afferent cerebrospinal nerves in the muscle and as a result there is deep pain It is suggested that where *superficial pain* is concerned the efferent effect is via the sympathetic. The muscle spasm may arise from vasomotor changes, or be due to a reflex resulting from the stimulation of "receptors" in the muscle.

It will be clear that these explanations, although they largely cover the facts, are somewhat constructed so that they should do so, and real experimental data are not yet available. They are given here so that the reader may have some explanation in his mind in dealing with these visceral types of backache Perhaps, however, the important point, not frequently made, is that although pain in a given viscus may normally be felt in the front of the abdomen, *any pathological condition in the back* may lead to its being felt there, and that subliminal stimuli may become effective for the same reason

It seems hardly necessary to set out tables showing the spinal segmental areas of referred pain from visceral disease. These will be found in most text-books of general medicine

Two Shortened Case Notes illustrating the difficulty in many cases of separating Visceral Pain from Pain due to Locomotor Disorder

E W Æt 43 Company Director

C/o backache (recurrent for many years) Pain in mid-back (D12) all day but not disabling much worse at night Massage makes it worse

On examination he was slightly overweight but healthy

Locomotor system —The pain is localised over the twelfth dorsal vertebra and radiates to the left along the intercostal space A localised stiffness of the spine at about this spot *X-ray* showed some slight lipping of the costovertebral joint The E S R was 6 mm at the hour (Westergren) but the blood uric acid was raised

Treatment —After anæsthetisation of the painful spot with procaine (which upset the patient considerably, but which was temporarily successful) and some physiotherapy, the patient was referred to an orthopædic surgeon for opinion In view of the localised character of the pain, the temporary relief with procaine, and X-ray confirmation of the lesion it was decided to do an arthrectomy of the 12th costovertebral joint on the left side

The pain was completely relieved and now (four years later) the patient is free of symptoms

L B Æt 57 Civil Servant

Had a severe accident during the London "blitz" and hurt his back This was followed by an attack of influenza Pain then began in the lower dorsal spine (D11) and radiated round the right side of the body to the epigastrium and to the nipple. When severe the pain made him vomit Any form of exercise, but particularly gardening, brought on the pain

P H Malaria and gout while abroad He was thrown out of a car in Africa and injured the ribs on the right side behind

On examination he was found to be an apparently healthy man, but there is some tenderness over the gall bladder Apart from this the general medical examination was negative

In the *locomotor system* a tender area was found in the back on the right side at the level of D11 Pressure on this spot reproduced the pain of which he complained and *if long continued made him feel sick* *X-ray* showed slight osteoarthritic changes at this joint only The barium meal was negative The *sedimentation rate* was normal, and the blood uric acid 3 7 mg per 100 c c

Passive movement of a manipulative nature relieved the pain for some time but when it came back he felt ill, and was sick Subsequently he developed an urticarial rash on his neck Tests for occult blood and examination for ova and cysts in the stool were negative

By marking the tender spot with a penny the X-ray localised it as being over the head of the rib (D11), and the radiologist was of opinion that it was subluxated The only abnormal pathological or biochemical finding was an eosinophilia of 10 per cent The posterior root of the twelfth dorsal nerve was injected with procaine and the pain was relieved for 24 hours The opinion was given that the pain and sickness were probably due to the subluxated rib An orthopædic opinion was obtained which did not agree with this view, because the radiation of the pain did not correspond to the spinal distribution, and suggested gall-bladder investigation It was decided to send the man into a nursing home for complete overhaul The day the patient arrived there he fainted and brought up some blood He recovered from this but four days later he had a large hæmatemesis An emergency operation showed a large ulcer in the duodenum with an artery bleeding profu

The ulcer penetrated deeply into the pancreas. After operation and transfusion he recovered a good deal, but three days later he died after a further hæmatemesis.

This case seems to illustrate the point that a locomotor lesion in the back may localise symptoms to this point, although it is well known that an ulcer penetrating in to the pancreas causes back pain.

BACKACHE DUE TO DISORDERS OF THE LOCOMOTOR SYSTEM

(*a*) In the bones

Any primary or secondary neoplasm; any inflammatory condition such as tuberculosis of the spine or sacro-iliac joints; syphilis or osteomyelitis; the "typhoid" spine, and conditions the causes of



Fig 238

The appearance of secondary metastases in the bones from carcinoma of the prostate.

which are somewhat understood, such as hyperparathyroidism and osteomalacia, or of unknown origin, such as Paget's Disease; osteochondritis of the spine, and injury; spinal osteoporosis of unknown origin; adolescent kyphosis

Some difficulty may be met with in distinguishing some of these conditions, but the X-ray is decisive in many cases. Typhoid spine sometimes leads to kyphosis, but it only occurs after typhoid fever, and the Widal will usually be positive. Calve's Disease, osteochondritis of the spine, leads to a wedge-shaped, flattened vertebra, and should not be confused with other conditions. It can be separated from tuberculosis of the spine, as the intervertebral discs on each side of the vertebra are radiologically normal. In 1891 Kummel

described a condition which is often ascribed to trauma, but the aetiology is uncertain In many cases an injury occurs *followed* by immediate pain which gets better. The patient goes about his work, and many months later the pain returns and is followed after an interval by deformity, e g kyphosis. The site of the lesion is usually 4–7 dorsal. A great many authorities still think the condition is due to a compression fracture. The pathology is a rarefying osteitis, but in addition some think the intervertebral discs play a part

The less well known syndromes in the list will be dealt with by Hunter in his chapter on medical diseases of bone; the others are self-evident

Spinal Osteoporosis of Unknown Origin

Burrows and Graham (1945) have recently given a very complete description of 20 patients with this condition and two necropsies

The condition is not common, but these authors saw 17 such patients between September 1939 and 1943. The syndrome occurs in men between 40–70 years, but in women later, so that the peak of incidence in all cases lies in the 60–70 decade In 208 cases aged 45–87 years, Black, Ghormley, and Camp (1941) found 41 men and 167 women Other authors have found even fewer men Albright *et al* (1940 and 1941) found only 2 men amongst 42 patients who were less than 65, and were inclined to consider the condition a post-menopausal osteoporosis, partly perhaps on account of the beneficial effects they obtained with the oestrogens

Symptoms may be absent Others have very severe pain in the low back brought on by some trivial movement Some patients feel something "give" in the back. One patient some years ago felt this happen as she dealt a pack of cards The pain at this stage may either be mild or extremely severe

Burrows and Graham found kyphosis or kyphoscoliosis in all their cases Other authors (especially some of the older ones) have

the most affected The intervertebral concavity appears to be filled with a thickened intervertebral disc Schmorl's nodes (herniation of the nucleus into the vertebral body) are seen occasionally With the concavities some "wedging" occurs With the spinal changes the spinous processes tend to approximate and "pseudoarthroses" sometimes occur.

Ætiology is unknown Deficient diet has been suggested, especially calcium and phosphorus deficiencies, and the effect of wartime diet is considered by Burrows and Graham in detail

Other possibilities are habitual purgation, excessive intake of alkalis, and various endocrine factors

The biochemical findings are indecisive. Blood phosphatase is

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The patients are usually aged 10–15 years and there are more boys than girls. A good many patients do not complain at this age but attend later in life with the established deformity, the X-ray changes, and complaint of pain and deformity.

Treatment is mostly directed to rest and exercises to increase spinal mobility.



Fig 239

An anterior posterior view of a severe case of scoliosis which was accompanied by kyphosis and started in adolescence

Vertebral epiphysitis (Steindler, 1929) is often confused with the above syndrome and some say that it is in fact a precursor of adolescent kyphosis The epiphyses of the vertebral epiphyseal ring appeared about the age of 14 and joined up about the age of 25 This is a not uncommon cause of backache

(*b*) In the spinal supporting structures and cord space

Ankylosing spondylitis, osteoarthritis of the spine, extramedullary tumour, herniation of the nucleus pulposus and protrusion of the annulus fibrosus, calcification of the intervertebral discs; rheumatoid arthritis of the apophyseal joints, transversosacral

near normal The E.S.R. is normal, if other causes for its rise are excluded

Differential Diagnosis

This type of spinal osteoporosis must be distinguished from that due to puerperal and "hunger" osteomalacia. Both types of osteomalacia, apart from their distinguishing associated factors, tend to show a waddling gait, bony tenderness and spasm of the adductor muscles, and are found with a low blood calcium and sometimes tetany with its accompanying physical signs. None of Burrows and Graham's cases had these associations.

The *pathological picture* also is different. Hadfield reported three main abnormalities: simple atrophy of the vertebral bodies, prolapse of the annulus fibrosus into the bodies, and loss of continuity of the cartilaginous plates. Other difficulties in diagnosis may be encountered. Malignant new growths, fibrositis and arthritis, ankylosing spondylitis and spondylolisthesis have to be excluded. Diseases *involving the bone marrow such as myelomatosis can be associated* with spinal osteoporosis, so that the Bence-Jones protein should be looked for in the urine. The X-ray will dispose of such possibilities as Paget's Disease, Kümmel's Disease, Senile Kyphosis. Cushing's syndrome is associated with obesity and hypertension. Complete blood examination is necessary to establish the diagnosis of the syndrome under consideration. Those interested should read this excellent paper in the original.

Treatment.—Burrows and Graham recommend calcium-phosphate 1 g t.d s. Leitch (1936) calculated the loss of calcium to be about 91 mg. daily over a period of ten years At least double this amount would have to be given *and absorbed* to be effective. The criteria necessary for the absorption of calcium are complex and cannot be discussed here, but vitamin D is known to promote the absorption of both calcium and phosphorus Although 300,000 units a day or more have been given for rheumatoid arthritis, the conditions here are different, and some authors have reported unfortunate results, including nephritis Nevertheless, small doses could do little harm and might do much good. One thousand units a day might be adequate for the purpose

Burrows and Graham emphasise the importance of orthopædic assistance and of this there is no doubt.

Adolescent kyphosis (Scheuermann's Disease) is not properly understood. Probably Schmorl's explanation is the best. He supposes that there is prolapse of nuclear material into the vertebral body, with narrowing of the intervertebral space, and so direct pressure is exerted on the bone If this is not evenly distributed, and the "jaws of the vice" close anteriorly, as they must do because of the hinge effect of the articular facets, kyphosis ensues The X-ray appearances show *notches* at the lower and anterior portions of the bodies of an increased size, *secondary changes* occur round the nuclear prolapse (when present), and *wedging* of the bodies is seen. An *epiphysitis* may be the primary lesion.

The patients are usually aged 10–15 years and there are more boys than girls A good many patients do not complain at this age but attend later in life with the established deformity, the X-ray changes, and complaint of pain and deformity

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arthritis; spondylolisthesis; strains or sprains or fibrositic infiltration of any of the spinal or perispinal ligaments or fasciæ.

Ankylosing spondylitis and *osteoarthritis of the spine* have their own chapters; *herniation of the nucleus pulposus* and *protrusion of the*



Fig 240

This X-ray shows the changes of tuberculosis in the sacro-iliac joints This is a very important diagnosis to make as the treatment is naturally quite different

annulus fibrosus and *extramedullary spinal tumour* are described in the chapter on Sciatica, as is *transversosacral arthritis*.

Calcification of Nucleus Pulposus and of Fibres of the Annulus Fibrosus

An uncommon but not rare type of backache is associated with this type of calcification. The pain is usually in the back but may radiate round the body. It is of a very chronic and continuing nature, but is usually situated in the low dorsal or upper lumbar

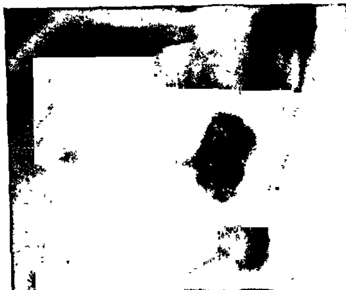


Fig 241

Another case of calcification of the nucleus pulposus with radiating pain round the body which defied all methods of treatment.



Fig 242

Lateral X ray of the spine showing in the upper portion calcification of the nucleus pulposus In the lower part there are apparently small areas of calcification in the anterior portion of the annulus fibrosus The symptoms here are intractable backache which sometimes has been known to respond to deep X ray treatment

region. Limitation of movement of the part affected is very usual The mechanism by which the pain is produced is not properly understood, as quite often only the nucleus itself is affected. When



FIG 243

Occasionally hyperæsthesia is found in lesions involving the intervertebral discs or the apophyseal joints This picture shows the hyperæsthesia found in one particular case

poor blood supply and tissues which are subject to ossification. All these factors are present in the discs, so that metaplasia of connective tissue cells may take place leading to the production of osteoblasts which secrete phosphatase and lay down calcium phosphate.

Attempts to show differences in blood phosphatase either in this condition or in ankylosing spondylitis (where calcification of ligaments is such a marked feature) have failed The idea is beginning to emerge that calcification of tissues is a non-specific reaction and may be the result of many insults and traumata. Certain biochemical considerations enter into the question.

THE EXAMINATION OF AN OBSCURE CASE OF BACKACHE

History-taking is all-important.

Age, sex and occupation are important factors. If the *occupation* is of a manual nature it is wise to inquire whether any special attitude is adopted while working The *menopause* is sometimes a factor in chronic backache, and a gynæcological opinion will be needed.



FIG. 245

This X-ray shows the differences in joint space between adjoining vertebræ These differences are generally thought to be due to fibrosis and dehydration in the intervertebral discs, and sometimes lead to symptoms, especially if the loss of space is asymmetrical

Circumstances at the time the pain first appeared may be helpful. In particular the relationship to any injury should be noted, and whether the pain came on suddenly or gradually. The *duration* and *site* of the pain will be noted, and whether it is always in the same place or moves about. *Factors which influence the pain* are important, especially any relationship to defæcation, and the influence of exercise, coughing and sneezing *Severity of the pain* is not useful as so much depends on personal evaluation. Any *evidence of neurosis* should be treated with reserve, but noted *The time of day* at which the pain is worst sometimes gives an indication of its source The *effect of the pain* on sleep is helpful.

The physical examination —The *general medical examination* must be thorough and complete, and must include an examination of all

systems, including the central nervous system. The examination of the urine must not be overlooked. Any special features found will be further investigated by X-ray and laboratory methods

Having excluded general medical causes, the locomotor system must be examined in detail. The *whole of the spine* must be examined for tenderness, limitation of movement and strength With the patient prone the muscles, fasciæ and ligaments must be carefully probed for tender spots If found, some attempt must be made to put these "spots" on the stretch by manipulation The pain so produced is sometimes useful in locating the *depth* of the lesion If the pain is, as it usually is, in the low back, the Mennell modification o the Lasègue test has sometimes seemed useful in separating out sacro-iliac conditions, but some authors mistrust it Carefully examine all joints, but particularly the shoulders and hips

The *posture* should be examined, and note made of abnormalities It was well to look at the posture from *all* angles, as small variations from the norma sometimes produce much in the way of symptoms Determine the leve of the anterior superior spines and the length of the legs A careful examination of the *feet* should be made A rectal examination is essential.

X-rays of the spine should include special views of the *apophyseal joints* and pictures should always be taken of the *sacro-iliac joints*

Estimations of the *sedimentation rate* and the blood uric acid should be carried out as a routine

THE LESIONS WHICH COMPRISE THE REALLY COMMON CAUSES OF BACKACHE

1 *Strains and sprains of the muscles and of the spinal and paraspinal ligaments*
2 *Injury*
3 *Postural defects*
4 *Fibrositis of the muscles and ligaments.*
5 *Herniation of fascial fat*

Lumbosacral and Sacro-iliac Strains

It is usually taught that these lesions are amongst the most important of the causes of backache and are said to occur in the proportion lumbosacral 5 to sacro-iliac 1 The reasons for this are that the steering force is greatest at the lumbosacral junction and that the sacro-iliac joints are the most strongly reinforced in the body

These strains are largely caused by *trauma* and the type of injury determines the lesion Torsional injuries due to a sudden twist of the body generally lead to sacro-iliac strain, sudden forcible flexion to lumbosacral injury

Other causes are posture and occupation, especially abnormal strains due to unequal length of the lower limbs. One other cause of pain in these ligaments is the effect of the hormone "relaxin" in pregnancy In 1854 Duncan published observations showing that

the pelvic ligaments relaxed during pregnancy and parturition. In 1929 Hisaw *et al.* demonstrated the relaxation that occurs in guinea-pigs and in 1946 Hall and Newton published a note in the *Lancet* showing the same action in the mouse. They used this mechanism as an objective test for relaxin After Hisaw's original work it was shown that œstrogen and progesterone might have a similar effect, but in 1944 Hisaw produced evidence which appears to reinstate relaxin as a physiological entity A good deal of the pain and disability after pregnancy may be due to the effect of relaxin on the ligaments and failure to recover therefrom. *Subluxation of the sacro-iliac joint* is a fairly common sequel.

How to distinguish the strains—The *point of tenderness* usually differs in the different types Usually these points lie over the ligament concerned.

Movements which reproduce the pain are often those which caused it Thus a painful pelvic twist usually suggests a sacro-iliac lesion; painful forced spinal flexion a lumbosacral lesion. *Raising the head with the patient supine stretches the ligaments all the way down the spine* and is a useful test. Local anæsthesia may be tried but is not so successful as in muscular lesions *Compressing the anterior superior spines* together is painful in sacro-iliac lesions but not in lumbosacral cases *Flexion of the thigh* may be painful in either case but is usually more painful in sacro-iliac strains The rectal examination is said to be painful in sacro-iliac cases. This is a very unreliable sign Other lists are recommended but are not very useful

Treatment consists either of manipulation or immobilisation The best plan is to immobilise until the acute phase passes off, and then use physiotherapy methods such as heat, massage and exercises If this leaves some residual pain, manipulation is often successful It is as well to remember that the interspinous ligament between L5 and S1 cannot be stretched adequately under anæsthesia. If this ligament is at fault, local anæsthesia may be tried, or surgery invoked

If any of the ligaments are tender and associated with pain, suberythema doses of Kromayer (see Physical Therapy) lamp may be applied over the tender spots This is very effective when the posterior sacral ligaments are involved.

Postural defects have been dealt with elsewhere. Lumbar lordosis is the commonest, and is often associated with contracture of the hamstrings.

Coccygodynia or the painful coccyx is a most troublesome complaint Most authors say that it is usually associated with trauma, but this is doubtful. It often comes without any such history. In other cases it is associated with such conditions as ankylosing spondylitis

The *salient features* are pain over the coccyx especially noticeable on sitting This is usually accompanied by pain on defæcation The coccyx is very tender and a rectal examination gives great pain

Treatment is very difficult and often not effective The most useful is rectal diathermy, if the electrode can be introduced. Strapping the back up sometimes helps Injections of novocaine

into tender areas does not relieve as a rule. Comroe reports Thiele as saying that spasm of the levator ani and/or coccygeus muscles often occurred, accompanied sometimes by spasm of the pyriform

Psychotherapy as a last resort is recommended Personal experience is that it may make matters worse.



FIG 246

A very advanced example of osteoarthritis of the spine with "parrot beak" osteophytes

Fibrositis of the muscles and ligaments is dealt with in the

in which subluxation of the inferior articular processes of the fifth lumbar vertebra is a feature may have an independent existence There are no *physical signs* by which it can be distinguished, and it

of the couch. The physician stands at the foot of the couch and the patient's hip and knee are flexed. The ankle is held and a pull is given as the patient is asked to kick out. The two movements should coincide. This movement is repeated several times, and physiotherapeutic measures follow. In some cases where *other measures have proved disappointing* these manœuvres may prove helpful *The horizontal or nearly horizontal sacrum* is a potential cause of backache quite apart from the question of spondylolisthesis. *Prophylactic measures* such as support for the lumbosacral joint and faradism to strengthen the muscles are the most effective

In many cases of backache orthopædic help at an early stage is essential

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CHAPTER XXXIII

THE FOOT

COMPLAINTS either directly or indirectly related to the foot are of considerable frequency in practice, and many of these patients may be helped by relatively simple means. Lesions mainly of surgical interest will only be mentioned and operative procedures will not be described

In the diagnosis of the painful foot both general and local causes must be considered The foot is not an isolated organ and, when systemic disease has been eliminated, the cause of pain in the foot may be found in some other part of the body. Vascular disease, neurological disorders, renal and cardiac failure are causes of painful feet, nor must the impact of such diseases as diabetes mellitus or syphilis escape notice

Vascular Disease is a not uncommon cause of pain in the foot, especially in elderly persons This ischæmic pain is most frequently found in association with *arteriosclerosis* but association with *Buerger's Disease*, diabetes mellitus, or luetic endarteritis may influence the therapeutic measures employed The case usually presents with so-called "rest pain," found chiefly at nights and described as a severe ache occurring either in the region of the heel or in the ball of the foot Ischæmic pain may occur in conjunction with the

minimal

Raynaud's Disease causes little difficulty, its peculiar age and sex incidence and the fact that by the time the legs are affected the

vascular phenomena, the attacks are sometimes induced by warmth of the part and so appear when the patient is in bed Local arteriosclerosis or polycythæmia sometimes cause unilateral areas of redness accompanied by burning pain without, however, any rise of temperature

Acrocyanosis requires mention only as an unimportant anomaly causing confusion in the differential diagnosis

The late effects of "*immersion foot*" sometimes produce vasomotor phenomena not always distinguishable, if indeed they do differ from erythromelalgia

Neurological disorders will most often appear as a peripheral neuritis and the ultimate diagnosis of this condition will require the

elimination of such causes as diabetes mellitus, pernicious anæmia, vitamin B deficiency, etc. *Gross neurological disease such as* hemiplegia or myopathy will [illegible] des which infrequently gives rise to pa [illegible] disturbed to produce great changes in [illegible] is much impaired

Tabetic pains may rarely affect the foot and should be borne in mind

Patients complaining of œdema of the feet must, of course, receive a thorough examination to exclude cardiac or renal disease, pelvic masses, or other serious findings.

Tumour

Tumours are not infrequent and exhibit *no striking differences* from those found in other parts of the body.

Osteochondropathies

Several varieties of epiphysitis affect the feet, these are named after their discoverers In all there is apparently a relation to trauma and in all the X-ray changes are rather similar, including rarefaction, fragmentation, or abnormal calcification. These diseases occur in children, as it is an essential prerequisite that the epiphysis shall be ununited

Calcaneal apophysitis is the commonest of these disorders, as the calcaneal epiphysis is subject to trauma from walking and is the site of insertion of strong muscles. The onset is with pain in the heel, pain in the calf muscles, or Achilles tendon, usually made worse by climbing stairs Males particularly between the ages of ten to seventeen are the most frequent sufferers, the condition is frequently bilateral. Examination shows local tenderness at the insertion of *the Achilles tendon, limitation of forced dorsiflexion owing to pain,* and a tendency to walk upon the toes. The diagnosis is confirmed by X-ray examination, which shows osteosclerosis, irregularities of ossification, and sometimes separation or malalignment of the epiphysis.

The treatment includes rest of the diseased part during the acute stage with, if necessary, heat and massage to relieve pain. In some cases it is necessary to apply a plaster cast and immobilisation of the foot in slight plantar flexion for a period of weeks (See Chapter XXV)

Kohler's Disease affects the tarsal navicular bone, which shows delayed development, osteosclerosis and a disc-like configuration on the X-ray (Fig. 000). The symptoms include localised pain, swelling *and tenderness of the dorsum of the foot over the navicular,* frequently accompanied by a limp. Treatment is usually confined to symptomatic relief, as healing is practically invariable.

Freiberg's osteochondropathy usually affects the head of the second metatarsal but infrequently the heads of the other metatarsals may be affected. X-ray reveals that the head of the second metatarsal shows

deformity, fragmentation and change in density. The symptoms are chiefly local in nature and treatment requires either prevention of weight-bearing or a re-allocation of weight distributed by a stout metatarsal bar or an anterior metatarsal pad. Occasionally surgery is invoked to remove the metatarsal head. (See Chapter XXV.)

March fracture.—March fracture is a lesion that has become increasingly prominent of late The patient is usually a young adult who has recently undertaken some unusual exertion. This condition is often seen in Army recruits, but sometimes occurs in seasoned soldiers The chief symptom is local pain which in the more severe cases may be accompanied by local swelling, bruising and a palpable mass The lesion is usually seen in the metatarsals but most portions of the foot have been involved at one time or another X-ray examination may not always show a fracture but usually discloses slight periosteal new bone formation. Later the mass of periosteal new bone increases considerably and may be palpable

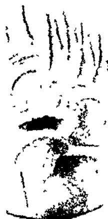


FIG. 247

Köhler's Disease

An X-ray showing the typical picture

Treatment is subject to individual taste It is necessary to prohibit weight-bearing till the pain has been relieved Some surgeons treat the patients in plaster The usual period of disability is three to four weeks, but is sometimes less It is important to diagnose the lesion, as if trauma is allowed to continue the lesion sometimes becomes progressive, with either an impacted fracture or complete displacement of the fragments

Evolution of the Foot

The evolution of the human foot is as yet incompletely understood, largely owing to the lack of suitable specimens for study. Certain broad trends can, however, be distinguished.

(1) The assumption of the erect posture with the ultimate development of alignment of the centres of gravity of the pelvic and suprapelvic structures with the tibia, and the consequent change of tibial inclination, appears to be the primary change Keeping the centre of gravity within the base has caused secondary changes, whilst the increased amount of weight transmitted through the feet and the loss of their grasping function has resulted in other secondary changes

(2) Considerable reduction in the size of the forefoot and its relative importance in weight-bearing has occurred simultaneously with the development and increased function of the heel

(3) A marked increase of the inner section of the foot with the production of the big toe is a further feature

(4) Approximation of the metatarsal of the big toe to those of the other toes accompanied by a great regression of the muscles which formerly opposed the great toe to the other digits.

(5) The picture drawn so vividly by Keith, in which the muscles originally serving prehension, whilst retaining in the main their anatomical relationship, take on a new function in stabilising the foot when applied to the ground, and in maintaining and producing the arches of the foot

It is likely that the human foot has not yet reached its final evolutionary form, and many of the troubles to which it is heir can be traced to congenital abnormalities or regressions to a less specialised state.

Weight Distribution

The centre of gravity of the body is normally based over a triangle, the apex of which is the calcaneum, the base being the metatarsal heads. Measurements of the relative forces applied to these points have been made by Morton (1935), who used a divided platform equipped with separate scales. His figures are generally accepted. For an individual weighing 120 lb., 60 lb. will be applied to each leg, and will be borne by: heel, 30 lb, 1st metatarsal, 10 lb., other metatarsal, 5 lb. These figures refer to the foot in the standing position and are, of course, only approximate. The heel thus takes 50 per cent. of the body weight, whilst the 1st metatarsal bears twice as much weight as any other metatarsal (30 per cent. of the remaining weight). This transference of weight to the 1st metatarsal has had a profound influence on the human foot as this metatarsal, from an evolutionary standpoint, was not primarily a weight-bearing bone, being the great grasping and balancing portion of the foot. It is no coincidence that so many foot disorders originate in this segment.

Arches of the foot.—The anatomy of the foot arches has already been considered. The purpose of the arches is to provide resilience to the foot and thus to allow the necessary adaptation of its shape when traversing rough country The almost universal use by civilised races of a nearly rigid shoe largely handicaps this function of the foot The use of footwear is almost obligatory owing to the hard surfaces of roads and cannot be regarded as wholly evil. Footwear can be seen as a logical aid to an organ ill adapted to artificial conditions This remark can be applied only to properly designed and constructed footwear, as it is undoubtedly true that certain shoes impede rather than help the adaptation of this organ to its present function.

Controversy surrounds the precise mechanism by which the arch is maintained. The factors involved are:

(1) The shape of the bones.
(2) The short muscles of the sole and the long muscle tendons.
(3) The ligaments.

All are agreed that the main factor in arch maintenance is the muscles, particularly the lower leg muscles When standing, however, conditions are different and certain authorities, whilst not denying the influence of muscle tone, believe that the ligaments play a significant part in maintaining the structure Many of the differences in management adopted by various surgeons have their root in this indecision.

Examination of the Foot

The general posture of the patient should be examined with

normally be found to pass between the first and second toes With the abducted and pronated weak foot this line may fall mesial to the big toe

The weight distribution as measured by the patient placing one foot on each of two scales often gives valuable information, especially in the case of obscure backache It is important that the patient shall not see the reading of the scales as this weight-distribution test is easily upset by voluntary correction

Footprints can easily be taken by moistening the soles of the patient's feet and requiring the patient to walk upon a sheet of stout brown paper, the impressions can be made permanent by tracing round the moistened area with a pencil Better information is afforded by the use of rather more elaborate types of apparatus for this purpose Morton's "Kinetograph" consists of a corrugated rubber mat covered by inked fabric on top of which lies the record paper covered by a cloth The thickness of the lines produced by the footprint is roughly proportional to the weight applied at each area A rather similar apparatus is described by Lake and is equally satisfactory. It is valuable to obtain two sets of footprints in difficult cases, one when the patient walks and the other with the patient standing Inspection of the shoes gives information as to the habitual walking attitude, whilst callosities on the feet likewise indicate sites of weight transference Examination should be performed both during weight-bearing and without weight-bearing

The general appearance of the foot should be noted, the skin colour, the presence or absence of sweating, temperature, epidermophytosis, the state of nutrition of the nails, the pulsation of the dorsalis pedis and post-tibial arteries, abnormalities of the toes and, where required, sensation and reflexes

After the patient has indicated the site or sites of pain, careful palpation of both feet is carried out Next the patient is requested to carry out active movements, testing the mobility of the foot, and lastly passive movements are carried out to determine whether

Flat Foot and Foot Strain

These entities must, perforce, be considered together as they are sometimes synonymous diagnoses owing to differences of diagnostic criteria. The true flat foot is not as common a condition as is generally thought, owing to the wide variation in the height of the longitudinal arch amongst various individuals. The height of the longitudinal arch is no measure of its efficiency. Similarly the assumption of an abducted and partly pronated position by the weak foot closely simulates the fallen arch unless this source of error is recognised.

The foot is a naturally strong structure and will stand up to a considerable amount of misuse, even if certain of the causes of



Fig. 248

A case of flat feet with os trigonum

weakness to be mentioned later are present. A proper classification is difficult but the matter is probably best considered under an empiric classification.

Congenital Abnormalities

The great importance of the *1st metatarsal segment* for the proper functioning of the foot has already been stressed. Certain abnormalities probably to be correlated to the deficient evolutionary progress of the foot are of prime importance.

(a) *A short 1st metatarsal* will not bear its proper share of weight and this will cause the 2nd metatarsal to bear an abnormal burden with consequent hypertrophy of this bone and the production of symptoms.

(b) *Metatarsus varus primus* is a congenital abnormality where the 1st metatarsal segment is not properly opposed to the 2nd segment, approximating to the more primitive conditions of the apes. Again the 2nd metatarsal segment undergoes excess load.

(c) *Hypermobility of the 1st metatarsal segment* has a similar action to the previous two conditions

Acquired Conditions

(a) *Hallux valgus* produces a tendency for the feet to pronate.

(b) *Trauma* may cause directly or indirectly abnormal weight distribution.

(c) *A short Achilles tendon* either congenitally present or due to excessive use of high-heeled shoes with compensating shortening of the tendon does not permit dorsiflexion of the foot Weight has to be borne on the anterior weak part of the foot, this tends to roll the calcanean inward and depress the longitudinal arch

Weakness or Deficiency of the Leg and Foot Muscles from a variety of causes leads to a weak foot

Disease such as Gonococcal Arthritis may cause rapid complete flat foot, usually the progress of the disability is slow.

Change of Lines of Force as in knock-knee or bow-leg may alter the weight distribution



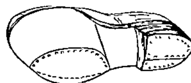


Fig 249

Shoes corrected with cleats medial wedge on heel and lateral wedge on sole, for the correction of stance in cases of flat feet

Two very important secondary and aggravating causes still remain.

Vocational Ætiology is seen in those whose work compels them to stand for long periods on hard surfaces, workers in factories, policemen, etc Excess weight either through obesity or pregnancy not only acts as an additional burden, but also increases the load on the anterior portion of the foot owing to the different weight distribution produced by the forward movement of the centre of gravity From all these causes the foot may fail and it is a tribute to its strength that the failure is usually due to more than one cause.

With many cases of weak feet a vicious circle is established as the position of pronation and abduction that results merely causes loads to fall upon structures unable to support them, with consequent increase in the deformity. The pain of a strained foot probably

separated to any extent a further increase in deformity results, owing to the fact that the head of the talus presses vertically

Abduction of the Feet produces a further disturbance in body mechanics as a compensatory internal rotation of the knees and hips results The internal rotation of the hips causes a tilting

forward of the upper portion of the pelvis, producing a lumbar lordosis to compensate for the backward position of the shoulders adopted to maintain equilibrium. This excessive lumbar lordosis may result in or aggravate backache. In children the internal rotation at the knee joint predisposes to knock-knee.

Symptoms

The chief complaints are ready tiring of the feet with pain. The pain is often widely distributed, but usually with its greatest intensity located on the medial border of the feet. Pains and aches are frequently complained of in the calves and tibialis anterior. The character of the pain is variable; common descriptions include the words burning, sharp, dull, or stabbing. Later numbness or tingling of the feet may appear, together with œdema or profuse sweating.

Examination of the feet reveals the abducted pronated posture already described, with its altered line of weight balance. A lengthening of the inner border of the foot with tenderness usually around the region of the spring ligament. Marked wear of the shoes on the inner side and frequently the presence of callosites under the metatarsal heads and corns above them. X-ray examination may show one of the causes for this condition previously mentioned.

Treatment involves several aims

(a) Correction of pronation.
(b) Correction of the depressed arch.
(c) Treatment of the tired and spastic muscles.
(d) The restoration of a proper weight balance to the foot structure.

In some cases where the symptoms are acute, rest in bed will be necessary as an initial treatment. A light removable plaster cast is made to hold the feet in adduction and inversion, and to support the arch, whilst remedial exercises are prescribed to a point short of pain and fatigue. The whirlpool bath, if available, may be of assistance, and heat with massage is sometimes useful. When pain at rest has disappeared, as it will do very early, the patient is mobilised. The shoes must be corrected so as to maintain the advantage gained. In the majority of cases rest in bed will be unnecessary and the following programme may be started straight away.

Controversy surrounds the use of an arch support in some cases. [illegible] may be all that is required

[illegible]

elevated ⅛ inch. The heel should be completely removed and this wedge fitted under the heel. A Thomas heel (one extended on the medial side) may be fitted at the same time. The Thomas heel supports the shank of the shoe and allows an arch support, if fitted, to [illegible] inches fitted under

If an arch support is fitted it must be realised that its use is palliative till the muscles recover their tone and exercises must not be neglected. In cases where deficiency or abnormal mobility of the [illegible] X-ray or clinical examination, the [illegible] he 1st metatarsal, in order to cause [illegible] quota of weight, is often successful. The average height correction incorporated in an arch support is ⅛th to ¼ in. but is usually $\frac{3}{16}$th in. An arch support should preferably be of the combined anterior and longitudinal type. Lake (1943) has propounded the theory that an arch support does not actually support the arch as this is not naturally a weight-bearing structure, but works more to force the foot into a more satisfactory position

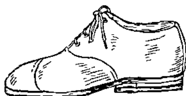


Fig. 250

Thomas heel. This extends forwards on the medial aspect of the foot and so relieves weight



Fig. 251

Metatarsal bar to take the weight of the heads of the metatarsals in those conditions associated with tenderness

in order to protect the sensitive instep from weight-bearing. "The arch support is thus a means of training the patient subconsciously to alter the weight distribution to the ground in the direction of relieving the inner border of the foot strain and allowing it to return to its normal position." This theory is an attractive one and possibly explains some of the undoubted benefit obtained by the use of this apparatus. Shoe correction includes not only the alteration of the weight-bearing stress on different parts of the individual foot, but also the equal balancing of the weight between the two feet. This latter point is determined by the twin bathroom scale test previously described. In order to avoid bulk in the shoe, corrections between the two feet should initially be by heel alteration only.

Coupled with these measures, efforts must be made to adjust the patient's life so that standing is reduced to a minimum; if this is impossible the patient must be told that benefit will result from shifting of posture as frequently as possible and perhaps walking a few paces every now and then. Higgs and Neely (1945) believe that

these measures are unnecessary and, in the absence of gross structural change, have found that the injection of 15 c c. of 2 per cent. procaine into every tender spot, followed by massage and gentle walking, repeated every third day if necessary, produces excellent results Reporting their results from the United States Navy, they stated that this treatment shortened the average period of disability from 33 to 6 days, halved the number of cases requiring admission to hospital and reduced recurrences from 70 per cent. to 2 per cent The suggestion that the strained ligaments hypertrophy with exercise is difficult to accept, but a few personal cases have tended to confirm their therapeutic results

Strapping of the longitudinal arch is frequently of value in acute foot-strain. Several strips of one-inch non-stretch adhesive strapping are applied. Commencing around the external malleolus the strapping is carried under the foot and half-way up the inner side of the leg, the foot being dorsiflexed and in the mid-position; to be of use this strapping should be firmly applied. The whole is finished with two horizontal strips, one at the highest position of the strapping and the other just above the malleolus; these merely retain the longitudinal portions in place and do not completely encircle the leg Less often relief may be afforded by strapping around the anterior metatarsal arch Faradic foot baths are sometimes used for the treatment of this condition, if long continued patients apparently derive benefit.

Pes Cavus

The factors involved in the production of pes cavus are.

(a) A congenital tendency to a high-arched foot.
(b) Unbalanced muscular action
(c) Contraction of the plantar fascia (? primary).

The chief complaint is of pain in the ball of the foot and dorsal pain with tiring in the longitudinal arches of the foot. Backache is not an infrequent complaint

On examination the foot is usually adducted, with the line of weight distribution running lateral to its usual position; the arch is high, the plantar fascia is contracted, as is the Achilles tendon, whilst there is tenderness under the metatarsal heads The aim of treatment is to redistribute the weight and to elevate the arch, thus relaxing the [illegible]
side by the [illegible]
the layers o[illegible]
beneath the 5th metatarsal A metatarsal bar is placed either internally or, better, externally across the sole just posterior to the heads of the metatarsals Such a bar causes weight transference to be posterior to the heads, and pressure is thus relieved. Exercises to stretch the short Achilles tendon and increase the tone of the intrinsic muscles of the foot should be given. The treatment of this condition by conservative means fails rather frequently, when surgery may have to be invoked

Morton's Metatarsalgia (Descent of the Metatarsal Arch)

This condition occurs chiefly in women The history is of sudden attacks of a burning or tingling sensation, noticed when walking By degrees this condition may become worse, the sudden shooting pain being sufficient to cause the patient to stop, remove the shoe and either to massage the foot or, more commonly, to squeeze the

and complains of constant disability, as even the slightest provocation may produce the attack Numbness of the 4th and 5th toes is not an uncommon symptom, whilst cramps in the posterior part of the foot also occur

l it to be
between
with the

facts to attribute the disability to compression by "dropped" metatarsal heads of nerve twigs. McElvenny (1943) has described the

such a syndrome, and even if it were constantly present the search for a causative factor would have to continue Examination of the foot is usually negative, except that in some cases the pain is reproducible by forcible reduction of the anterior metatarsal arch. There is sometimes an associated contraction of the toes which may lead to hammer-toe Recently King (King, Lester S (1946), *Am. J Clin Path*, **16**, 124) has investigated nerve tumours in five cases of this syndrome These tumours showed a thickened perineurim, but relatively few nerve bundles were noticed, although there was a considerable increase of fibrous tissue There was no inflammatory change in the sections and King concludes that these cases should be known as "sclerosing neuromata" to distinguish them from the ordinary amputation and traumatic cases This contribution, although relatively short, is thorough, and some good illustrations of the sections are shown

Treatment is directed towards removal of stress from the metatarsal heads A really adequate metatarsal bar is sometimes of considerable assistance, and this is usually better fitted externally. An elastic metatarsal strap with a bar fitted under the 4th metatarsal bone, but not extending to the head, fulfils two functions firstly it relieves pressure on the 4th metatarsal head and secondly it prevents the splaying of the metatarsals and thus imitates the procedure usually found effective by the patients of compressing the forefoot. Schuster (1939) obtained benefit in 80 per cent of cases by the injection of procaine The needle was inserted behind the 4th and 5th metatarsal heads and advanced at an angle of 45 degrees towards the bases of the metatarsal bones. When resistance was no longer noted, 3 c c of 2 per cent, procaine was injected, the procedure is

repeated in a week if required. In very severe cases, which resist treatment, excision of the 4th metatarsal head should be considered or exploration of the digital nerves.

The Painful Heel

Pain in the heel is a not uncommon complaint The pain is *usually present only when pressure is applied to the heel as in either* walking or standing. Tenderness is nearly always present. Pain in the heel shows frequent association with (*a*) a change in occupation which involves additional standing (*b*) a long debilitating illness. It is likely that both these causes are related to a deficiency either relative or absolute of the fibro-fatty heel pad. If such patients are treated early the response is frequently gratifying as the case tends to spontaneous cure *The first class of case, related to occupation,* will develop hypertrophy of the relatively deficient structures, whilst in the second class of case the natural processes of repair will tend to restore the normal heel pad. It is important to temporarily restrict the amount of standing and to prescribe the use of sponge-rubber heel-pieces to reduce the amount of trauma Many of these cases benefit from procaine injection of the tender spot These injections may have to be repeated on two or more occasions, pronounced relief usually follows.

Apophysitis of the calcanean has been previously considered Radiography plays an important part in the diagnosis of the painful heel as it reveals the rare cases of osteomyelitis (pyogenic and tuberculous) in children and the occasional case of tumour formation in the bone Sometimes definite calcaneal spurs may be revealed by this examination. It is important to realise that calcaneal spurs may be present without symptoms and it is a serious mistake to regard this finding as invariably responsible for pain in the heel Treatment should initially be as though the spur had not been found, occasionally surgical intervention to remove the spur through a lateral incision may be required

Plantar fasciculitis nearly always localises around the heel The treatment of this condition is by radiant heat, massage, heel pads and procaine injection

The occasional deposits of sodium biurate found in gouty persons must not be forgotten If formed in the fibro-fatty pad of the heel they may produce considerable disability. They may be removed by incisions placed outside the weight-bearing areas

Sometimes owing to faulty footwear a ridge of horny callus may produce symptoms The ridge should be gradually pared away, proper shoes insisted upon and, *if necessary, heel pads ordered.* Bursitis of the Achilles tendon is seen particularly in women who wear high-heeled shoes. Correct shoes, local protection of the area by elastoplast and rest will relieve the milder cases, surgical intervention may be required in the more severe types The occasional case of traumatic ruptures of the Achilles tendon will not usually cause any difficulty. This lesion should be under the care of a surgeon.

Miscellaneous

Plantar warts.—In adolescence the plantar wart often causes severe disability, it is found in front of the heel and in the ball of the foot These warts are infectious and this accounts for their prevalence in individuals of school age. The treatment of choice is by X-ray which is administered by a single massive dose, the rest of the foot being adequately screened It is important to realise that benefit may not be seen for as long as six weeks A second treatment if the first fails is not to be advised, as radiation ulcers may occur. Surgical treatment, if performed, must be thorough, with complete cauterisation of the base This operation produces considerable temporary disability and the patient must be warned of the result Care to avoid re-infection is essential and the patient should be instructed never to walk barefooted or wear other people's shoes.

Corns and callosities.—These are the result of pressure, and though local applications and treatment may be successful, re-formation will occur unless adjustments to relieve pressure on these points are made

Deformity of the Toes

Hallux valgus —This term is applied to the big toe when owing to its abducted position it lies on top of or underneath the other toes The first metatarsophalangeal joint is unduly prominent and may have a bursa situated over the medial aspect. The condition is in most cases due to narrow pointed shoes and raised heels Mild cases can be relieved by the wearing of shoes with a straight inner edge, stretching of the toe, and the insertion of a wedge between the 1st and 2nd toes during sleep A metatarsal strap is sometimes useful when the condition is aggravated by a splayed forefoot Severe cases eventually require surgical aid

Hallux rigidus implies limitation of dorsi- or plantar flexion of the great toe Sensible shoes will sometimes give symptomatic relief

Hammer-toe consists of an extension of the metatarsophalangeal joint and flexion at the proximal interphalangeal joint Medical treatment in the form of splinting, manipulation and pads is sometimes successful but surgery is sometimes required

Overlapping toes are a not uncommon cause of disability, caused in most cases by narrow shoes They are relieved by shoes with sufficient room in the anterior compartment toe pads and splinting

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CHAPTER XXXIV

PERIPHERAL VASCULAR DISORDERS

PERIPHERAL vascular disease is an important form of disability, which may, unless careful examination is employed, be misdiagnosed, with the resultant prescription of incorrect and aggravating treatment This fear is no theoretical bogy, as ill-advised physical treatment is capable of producing great harm

Physiology of Limb Circulation

An understanding of the elementary physiological control of the limb circulation is vital in both diagnosis and treatment. The four most important factors are:

(1) Nervous control.
(2) Chemical control (*a*) local, (*b*) general.
(3) The effects of temperature
(4) The arteriovenous anastomoses

The physiological functions of the limb circulation are five in number

(1) Acts as a part of the peripheral circulation in general adjustments of the vascular state of the body as a whole.
(2) Supplies the metabolic needs of the limb.
(3) Maintains the temperature of the limb so as to avoid damage from altered environmental states
(4) Plays an important part in the regulation of general body temperature
(5) Supplies the vascular component of inflammatory reactions in the limb

The circulatory status of the extremity is largely dependent upon the arterioles Limb arterioles may be roughly divided into two types: those which supply the skin (largely under nervous control) and those which supply the muscles (largely under chemical control) *The chemical control is exercised locally by the release of muscle metabolites which cause dilation of the vessels* A general chemical [illegible] This often shows a small dose of [illegible]s, but dilation of the muscle vessels

These two types of vessel control exhibit an exquisite mechanism of functional adjustment. The skin is largely controlled by central mechanisms, a necessity in view of its predominant rôle in the conservation and dissipation of heat, whilst the muscle vessels being under the control of local muscle metabolites are beautifully adjusted to the needs of the tissue supplied The realisation of this difference

is vital in both the diagnosis and treatment of peripheral vascular disorders, as under certain conditions these different types of control may lead to the skin vessels being contracted and the muscle vessels dilated, or vice versa. Many tests of limb vessels depend upon observations on skin vessels and it is only when certain conditions are fulfilled that these observations can be used even approximately to estimate muscle circulation. In treatment certain procedures that will at times improve one type of circulation may not improve the other, e g sympathectomy will often benefit selected cases with impaired skin circulation, but is frequently a failure where the muscle circulation is at fault

The effect of general chemical control of the circulation must not be forgotten, as after sympathectomy the vessels become abnormally sensitive to this factor, with the result that as time goes on much of the initial benefit of sympathectomy may be nullified

The third factor in the control of the limb circulation is the direct effect of temperature on the vessels. The vessels of the limb contract when cooled and dilate when heated. This mechanism is appropriate from the view of general body temperature regulation, as in cold environments body heat is conserved, whilst high external temperature encourages heat loss. However, the very efficiency of such a mechanism for general bodily welfare may imperil the limb, happily a fourth factor is present which comes into play to prevent such a catastrophe. The limbs possess in their peripheral parts specialised vascular structures, the arteriovenous anastomoses present in greatest number in the palm of the hand, the digits and the sole of the foot. These vessels are under nervous control and provide an efficient means of warming the limb from its tips, when the local temperature falls to a level sufficient to impair the vitality of the tissues

The effect of temperature on the limb circulation is therefore considerable and must always be taken into account or controlled when assessing the circulatory status of the limb. Similarly in heat or cold we possess potent means of controlling the limb circulation. A further effect of temperature is of great importance in this respect. Limb tissues, as other biological structures, are stimulated to high metabolic activity by heat, and show a depressed metabolism when subject to cold. A limb with an impaired circulation may show an even greater degree of impairment if heated, since the blood-flow demands have risen without a commensurate increase of blood flow

Examination

Numerous tests of vascular insufficiency have been introduced during recent years. Certain of these are relatively useless and will not be mentioned. It is helpful to divide the examination into four classes

(1) Tests which are part of physical examination
(2) Tests of capacity of vessels to dilate
(3) Tests of capacity of blood flow to muscle
(4) Tests of past damage to arteries

Physical Examination

From what has been said it will be obvious that the findings on physical examination, or with other tests, can *prove extremely* misleading unless carefully interpreted, due regard being paid to the presence of cold, fright, emotion, or other causes which may alter profoundly the circulation. Cold is the most important factor to control and its influence must always be remembered; thus if the dorsalis pedis artery cannot be felt in either limb, this cannot be regarded as definite evidence of occlusion of these vessels unless the limb is reasonably warm Tests to estimate the total potential circulation play a considerable part in diagnosis as, in these, inhibiting factors are as far as possible removed

Symmetrical limbs are examined together as comparison between the two is of great value. Local nutrition must be carefully assessed; atrophy of skin, ridging and curving of nails, the presence or absence of sweating are important points, later indolent ulceration or gangrene may appear Most careful search must be made for evidence of recent or past superficial thrombophlebitis, this is a cardinal point in the diagnosis of Buerger's Disease

The temperature of the skin is estimated by palpation with the dorsal surface of the digits This is a remarkably sensitive manner of detecting differences of surface temperature; comparison with the other limb is to be constantly made as differences between two limbs, subject to the same environmental state, are of great significance. Skin temperatures can be taken with a thermocouple, but this procedure is slow and provides no additional information at this stage.

Skin colour —The interpretation of this sign has been much aided by the work of Lewis (1936), who pointed out that three factors must always be considered together (*a*) the depth of colour, (*b*) the tint, (*c*) the temperature. The depth of colour is governed by the amount of blood contained within the minute skin vessels, and is not an indication of blood flow. Tint is a useful indicator, as if the blood is rapid little reduction of hæmoglobin takes place in the skin, the skin being pale or red depending on the depth of colour. If much reduced hæmoglobin is formed, shown by cyanotic tints, the blood is slow whilst if a violaceous tint is found the blood flow is very slow, or absent The temperature of the skin must be taken into account as a high temperature causes accelerated production of reduced hæmoglobin, whilst cold causes reduced production; if the temperature is very low (under 10° C) then dissociation of oxyhæmoglobin comes to a practical standstill and the skin will be red even though the blood flow is very slow Thus a warm pale or red skin is one in which the blood flow is good, whilst warm, deeply cyanosed skin is one to which the blood supply is imperfect but has been warmed. A cold pale cyanotic or deeply cyanotic skin means a very slow blood supply, whilst a cold deeply coloured red skin has the same significance, the depth of colour being produced by vessel dilation and the redness being due to the inability of the oxygen causing hæmoglobin to dissociate, it is possible to have a fair blood

supply in such a skin, but rather unusual It is important to realise that a normal skin may exhibit cyanosis over certain temperature ranges, usually 15°–25° C. Central cyanosis must be guarded against when considering skin colour

In normal limbs it is possible to palpate the femoral, popliteal, posterior tibial and dorsalis pedis artery in the leg, and in the arm the subclavian, brachial, ulnar and radial arteries Examination for pulsation of arteries takes little time and is a most important part of the examination.
bilateral loss of pulse
environmental tempe
information of value in deciding the possible significance

With the patient in the recumbent position, the leg should next be elevated, the normal warm limb shows incomplete blanching with this manœuvre, but a severely affected limb may show corpse-like blanching in ten seconds The phenomena is due to blood draining from the small vessels and not being replaced The limb is now placed in the dependent position and the rate of flushing and of venous filling observed, both will occur within ten seconds in a normal limb Care must be taken when observing venous filling to see that this is not due to filling from above via incompetent varicose veins. The blood pressure is now taken in the various limbs This will prevent coarctation of the aorta from being overlooked

Lastly a valuable test in some cases is the reproduction of the patient's complaint by exercise, heat, or cold Raynaud's Disease can be induced by immersing the extremities in cold water (15° C) This is a helpful procedure as it allows confirmation of the patient's story, and provides a better estimate of the severity of the disorder than would otherwise be obtained Details of other provocative tests are given later

Tests of Capacity of Vessels to dilate

These tests, of which numerous modifications are in use, provide information of great utility if used with discrimination

The simplest test and one which, owing to the little apparatus required, can be used as a routine is the production of reactive hyperæmia Reactive hyperæmia is the name given to the flush produced when circulation is allowed to return to a limb previously rendered ischæmic This test must be performed with rigid attention to detail The leg is warmed either by dry heat or, better, by immersion in a water-bath at 35° C for ten minutes The limb is then lifted out, dried, and raised above the level of the body, and if necessary gently massaged till the skin becomes pale The limb circulation is suddenly arrested by the rapid inflation of a sphygmanometer cuff to above the systolic pressure, the cuff is placed at the top of the thigh. The limb is lowered to the level of the body and kept warm At the end of five minutes the pressure is released and the bright flush that extends rapidly to the periphery is observed Normally the bright flush has spread to the tips of the digits in five

seconds, and has reached its maximum intensity in fifteen seconds The ischæmic limb shows delay in the spread of the flush, and delay in the production of its maximum intensity, which is sometimes cyanotic instead of red. Delayed appearance of the flush with diffuse development of the full colour indicates that a main artery is occluded, but that the collateral circulation is good. Delayed appearance with diffuse faint colour is indicative of disease of the finer vessels, or of a complete occlusion with a poor collateral circulation Delayed appearance with marked mottling is suggestive of severe impairment. It has been shown that the muscle capillaries also take part in reactive hyperæmia changes as would be expected, but it must be realised that this test is of the skin circulation and that impairment of the muscle circulation is possible though the skin circulation is nearly normal

Measurement of the skin temperature after procedures designed to produce *vasodilatation* are in common use. The *thermocouple* is usually used to obtain skin temperatures; other suitable machines have been described Any of the procedures mentioned previously may be advantageously performed when vasomotor tone is released; this is especially useful with regard to pulsation of arteries.

The most generally useful method for the release of vasomotor *tone is reflex heat, this may be applied in a number of ways: heat* cabinets, radiant-heat baths, or immersion of the untested extremities in hot water,

Vasodilator tests provide in conjunction with other tests:

(1) An estimate of the degree of arterial spasm present.
(2) The capacity for vasodilatation, and this gives some idea as to the possible effects of a sympathectomy.
(3) Some measure of the efficiency of the collateral circulation.
(4) A rough measure of the degree of arterial occlusion

Technique of test —The legs are allowed to cool in a room of even temperature for one hour The vasodilator procedure is then performed and readings of the skin temperature of both legs are then taken every two to five minutes, till the maximum reading has been obtained, the results are then plotted on a graph. The usual temperature attained by a limb extremity under such conditions is about 35° C If the limb does not reach 31° C. this is practically conclusive of some degree of cyanotic vascular disease Of great significance is any pronounced difference in either the final temperature or the rate of temperature rise between the two legs.

Vasospasm of the legs may be very intense and is not always completely removed by heat, thus if the response is unsatisfactory, and the question important, other vasodilator procedures of greater efficiency may be warranted. These comprise either spinal *anæsthesia* for the legs (very efficient), paravertebral procaine block for either leg or arm, or the procaine block of peripheral nerves. *Those chiefly* used for this purpose are the posterior tibial and ulnar nerves *to* block their respective distributions However, other nerves are also technically moderately easy of access and may be used. In view of

the recent alarming reports on spinal arachnoiditis following spinal anæsthesia, this procedure is better not employed

During vasodilator tests it is possible to take muscle temperature readings by using a hollow needle insulated except at the tips as one of the thermocouples As far as is known at the moment, muscle temperature change parallels that of the skin though the variations are less, when this test is employed Friedlander *et al* (1940) have reported that with different procedures this is not always so Until further work has been performed on the significance of changes of muscle temperature, skin temperatures will be adequate for clinical work

The intradermal histamine test—Normally the reaction to an intradermal histamine injection is the rapid production of a wheal as part of Lewis's triple response The formation of the wheal is dependent upon an adequate blood flow, if the local blood flow is deficient, the wheal either does not appear or forms more slowly

The warm extremity is placed in the horizontal position and either 0 1 c c of 1/1000 histamine is injected intradermally, or more satisfactorily is pricked through the skin This procedure is performed at various sites in the length of the limb The normal limb shows a substantial wheal at the end of five minutes, any delay beyond this period is regarded as showing an impaired circulation If no wheal appears at all (test solution on control surface) then gangrene is imminent If a wheal does not appear for fifteen minutes it is unwise to perform any surgical procedure at this level, as the skin is unlikely to heal This test has its greatest value in severe states of

Di[illegible]

due to occlusion of arteries, whilst that of acrocyanosis is due to occlusion of arterioles If histamine is pricked through the skin it does not reach the arteries, but does reach the arterioles Thus the Raynaud's cyanosis will not be changed by such a procedure, but the cyanosis of acrocyanosis will give rise to a brilliant red flare

Tests of Capacity of Blood Flow in Muscles

As yet we possess no satisfactory objective test of muscle blood flow, it is possible that muscle temperature studies may be ultimately developed to provide some assistance We are largely dependent [illegible] distance [illegible] testing it [illegible] precise by ergometric procedures i e measuring the work necessary to produce the pain Endeavours to render the test objective by electrical stimulation of muscles working against the ergometer do not at the moment appear to have increased the value of the test The "claudication distance" is a valuable check on the effectiveness of different therapeutic measures

Tests of Past Damage to Arteries

Oscillometer.—Used with care and with a knowledge of its limitations, the oscillometer provides useful information. If no oscillometer is available an anæroid sphygmanometer may be used as a substitute, though the oscillations will not be so wide. For practical purposes the oscillometer only shows the inflow to a limb via the *larger vessels*. A satisfactory collateral circulation may exist with practically no oscillometric readings. With this limitation in mind the oscillometer may be used to determine the patency of arteries where they are normally impalpable, and to demonstrate the site of blockage. The machine records evidence of past damage to arteries, and is not helpful in the estimation of the efficiency of compensatory measures. The instrument has especial value in localising the site of embolic obstruction or an arteriovenous aneurysm.

X-ray examination.—This is of limited value in advanced cases, where plates exposed with soft-tissue technique may reveal the calcification of arteriosclerotic arteries. It is important to realise that a calcified artery may have a patent lumen, and conversely the artery not visualised by X-ray examination may show the most advanced arteriosclerotic change with occlusion.

Arteriography.—Beautiful pictures contributing substantially to the diagnosis may be produced by arteriography. The ideal contrast agent for this examination has yet to be produced. Formerly thorotrast was used, but only with grave misgivings, as its radioactivity was regarded as dangerous. At the moment no valid data exists as to the actual danger, it is decidedly preferable to use a non-radioactive substitute. The usual material now used is 35 per cent. diodone (20 c.c.). Some workers expose the artery by surgery, but it is frequently possible to needle the vessel. Care in the interpretation of the arteriograms is necessary as local spasm may be produced by this technique-stimulating blockage. These spastic areas are not common if the body and extremity is kept warm during the injection. Some idea as to the extent of the collateral circulation may be gained from the films. Arteriography is not a procedure to be used routinely, but only for difficult cases. Certain special requirements, such as the localisation of an arteriovenous aneurysm, may necessitate its use.

Circulation times.—Development of circulation times to the study of limb circulation has not as yet been established. Spier *et al.* (1936) used a solution of calcium, magnesium and sodium salts to determine the circulation time to the limbs, the arrival of the mixture was marked by a warm sensation in the part. A similar effect is produced by calcium gluconate which is more readily available (10 per c.c. of 20 per cent.). Injection is made into the arm veins and the arm-tongue time is subtracted from the arm-foot time to give a rough ventricle foot time. Considerable variation of the ventricle foot time occurs in normals, but it is likely that any time of over 30 seconds (with body and limbs warm) is abnormal. Of greater significance is a marked difference in the time of arrival between the two feet.

This section has included a discussion of many tests, none give completely reliable results, all demand for their interpretation a knowledge of the physiology of the limb circulation Most cases will require no more than one or two of the special tests described It is only the application of all the data, and not just the result of tests, that gives a reasonable assessment of the limb circulation

ORGANIC DISEASE OF ARTERIES

1. Degenerative Arterial Disease

This subject is as yet very confused, both from its pathological and ætiological aspects That age in some way predisposes to arterial degeneration is certain, but other factors are also involved, and the relationship is likely to be indirect rather than direct

the predominant microscopic picture Mixed changes are very common, and it is uncertain what relationship exists between the three Diabetic vascular disease is an accepted entity, not on the basis of its microscopic picture, but on the known high incidence of this change occurring in the diabetic. The clinical picture produced by these changes is one due to arterial insufficiency, either the result of narrowing of the lumen or actual thrombosis of the lumen secondary to a degenerative plaque

Symptomatology.—Though arteriosclerosis must be regarded as a generalised disease, parts of the vascular tree may be almost completely spared when other parts are considerably affected The extremities may be only one of several parts of the body attacked, and manifestations of arterial insufficiency in other parts of the body may at times provide essential diagnostic clues Age is of great importance, the general rule is that the older the patient the more likely is the disease to be arteriosclerosis It is exceptional for arteriosclerosis to be the cause of defective limb circulation under forty years of age

(1) Atrophy of skin nails and muscle is a frequent early sign This may be accompanied by general muscle wasting and loss of weight

(2) Complaints of cold in the feet or hands are common, whilst sometimes sensations of numbness or pins and needles are present

(3) Intermittent claudication—a cramp-like pain, usually felt in the calves but sometimes found in the foot or thigh, induced by exercise and relieved by rest—is a cardinal symptom Prior to the development of intermittent claudication, unusual fatigue and weakness of the exercised extremity is noted The "claudication distance" is often remarkably constant for a given individual, and as with the pain of angina this distance is decreased by walking fast or going up hill, whilst cold weather tends to increase the severity Intermittent claudication is the result of ischæmia brought about by a blood flow

adequate for the needs of resting muscle, but inadequate for the needs of exercising muscle. It is important to note that intermittent claudication is a local phenomemon and is sometimes present when the main arteries to the limb are apparently patent; it must then be attributed to disease of the smaller vessels, a conclusion that has at times been supported by arteriographic studies.

(4) "Rest" pain occurs at nights and may be of considerable intensity. In this case it is probable that local areas of ischæmia develop owing to reduced local circulation and the formation of areas of local stagnation A further mechanism is that of ischæmic neuritis All pains occurring in the calf at night are not due to ischæmia. For instance, there is a common cramp, like pain which occurs in the calves of elderly persons, without evidence of diminished blood flow This for some obscure reason often responds to small doses of quinine (grm. 3 b.d)

(5) Ulceration and gangrene are late signs but when they occur are very troublesome, as healing or separation occurs only with great difficulty, and at any time a severe septic infection may endanger the limb or the patient's life. The ulcers are most frequently situated in the region of the toes, the plantar surface near the metatarsal heads, or on the anterior surface of the tibia. Gangrene nearly always starts in the digits or in a larger area that involves the digits Areas of gangrene, if uninfected, dry, and eventually separate, but the process is slow and often painful, at times surgery may be cautiously invoked to aid nature

2. Thrombo-angiitis obliterans (Buerger's Disease)

Buerger's Disease is one of completely unknown ætiology that attacks younger persons (20–40) and occurs predominantly in males Originally reported to occur almost exclusively in Polish Jews. This is now known to be incorrect, as it occurs in all races Jews show a high incidence. Tobacco is thought by some to be a factor of ætiological importance, practically all authorities regard its influence as deleterious on the course of the complaint.

The chief pathological changes comprise inflammatory *foci in the* arteries and veins, local thrombosis within the affected segments, subsequent organisation of the thrombus and adventitial reaction and scarring Lymphocytic infiltration of the adventitia and pronounced intimal proliferation are prominent features of the disorder Subsequent recanalisation of the lumen is possible, but not usually *of clinical importance, the burden of tissue nutrition being* borne by the collateral circulation

The disease process may be slow or rapid, and this renders both the prognosis and the assessment of therapeutic measures difficult. Since only some vessels are attacked and the rest of the vascular tree may be healthy considerable recovery from the effect of acute lesions is possible. The symptoms are predominantly those of reduced blood supply to the limb, so that the symptomatology described under arteriosclerosis is seen, though certain additional features are also present.

Migratory thrombophlebitis, due to the same pathological process found in the artery, is a frequent sign and a useful diagnostic
...date signs of arterial
... not present is no proof
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...on general grounds ... the management of actual occlusive lesions

Periarteritis nodosa usually occurs as a disease of bizarre signs and symptoms, rarely thrombo-angiitis obliterans may be mimicked

Treatment of Chronic Occlusive Vascular Disease

Treatment of the above three conditions has much in common. The cases with an underlying diabetic element will require, besides specific treatment for the diabetes, management as for other types of chronic ischæmia As no specific treatment exists for Buerger's Disease, this will be treated on similar lines

Whereas formerly the treatment of occlusive vascular disease was

regarded as a hopeless task, usually ending in amputation, modern understanding of the mechanisms at fault have led to certain advances which, if judiciously applied, may aid in preserving a functional limb.

All cases with occlusive vascular disease should stop smoking, this is imperative if Buerger's Disease is present, and even though the evidence as to its ill effects (blood-flow studies, etc) is not conclusive in other forms, this advice is wise.

Owing to the defective nutrition of the feet, lesions of these structures do not heal in the normal manner, and minor trauma of negligible importance in those with a normal circulation may become of tragic significance. The patient must treat his feet as though they were made of porcelain He must avoid crowds where they may be trodden upon; he must be careful not to stub his feet against the pavement; nails must be cut straight with great care; well-fitting shoes and socks are vital, epidermophytosis must be treated with the least irritating remedies available, corns may be carefully pared, but must not be treated with strong chemical remedies All minor surgery of the feet must be undertaken only after the most careful consideration and in the presence of an adequate circulation. Any break of continuity is an emergency, and the patient must be treated in bed till healing has occurred. The most satisfactory results are obtained by drying the lesion—a gentle draught of air from an electric fan is helpful

Gangrene or incipient gangrene is of very serious import, and it is best that the patient be hospitalised.

Exercise to the point of tolerance should be advised If intermittent claudication is present then the amount will be just short of the "claudication distance." Rest, unless necessitated by other features of the case, is harmful, as by this means the circulation is normally considerably reduced, and the stimulus to the formation of collateral channels lacking The aim should be to maintain the patient as near normal as possible, and this necessitates walking.

Buerger's exercises were introduced as a means of increasing the circulation by passive emptying and filling of vessels It is likely in the ischæmic limb that some degree of reactive hyperæmia occurs and helps to increase the blood flow, the exercise too is of value in bedridden patients. The great advantage of this treatment, useful in all types of chronic occlusive vascular disease, is that it requires little apparatus and can be used by the patient at home. A Buerger's board 40 inches long and with a hinged support that allows it to be inclined to 40°–60° should be provided. The top is covered by a folded towel to protect the heels

Starting from the horizontal position the limb is placed on top of the board for 1–3 minutes, depending upon the time necessary for the limb to blanch. The patient then hangs the limb over the side of the couch, maintaining this position for one minute longer than it takes for full rubor to be attained (2–5 minutes). The legs are then returned to the horizontal position for 5 minutes. When these various times have been ascertained for each individual patient,

he uses a clock to time the motions The legs and body should be kept warm during the cycle, and during the period of dependence a few simple foot exercises should be performed The cycles are generally started with 3 cycles t d s and then gradually worked up to about 1 hour's exercising 3 times a day

A similar type of passive filling and emptying is the basis for mechanical means of alternate suction and positive pressure as in the "pavex" boot or the "Burdick" apparatus. These machines, after receiving enthusiastic welcome on introduction, have declined in favour during recent years At the moment it is not possible to evaluate finally the efficiency of this mechanism A point that often causes trouble is that in order to maintain an airtight joint the junction between skin and ring has to be tight This sometimes causes the skin to become intolerant or break down

A mechanical means of providing Buerger's exercises without the co-operation of the patient and without fatigue has been provided by the Saunders' oscillating bed This apparatus has been well reported upon from the United States, but does not appear to have become established in England The oscillating bed is well tolerated by the patient and would appear to merit a wider use than has yet been accorded to it

The controlled use of heat in the management of this condition is helpful, but the remedy is liable to great abuse The limb with a poor blood supply *tolerates heat badly*, as not only is the local metabolism raised but any burn or other thermal trauma may prove serious With any of the conditions mentioned (except gangrene or incipient gangrene) the limb may be heated by thermostatically controlled heat cradles to not more than 32° C surface temperature This temperature is more than sufficient to overcome any local effect of cold upon the vessels Reflex heat (heat applied to other parts of the body) can be used to produce maximum vasodilatation and its use is advantageous either alone or in combination with other forms of therapy Other forms of physical therapy employing heat are also in use, contrast baths are not a satisfactory form of treatment, but on occasion the whirlpool bath may apparently provide relief

Pyrexia produced by injections of typhoid and other vaccines has been used to produce vasodilatation If used in small doses to produce a temperature of not more than 102° F its use is not unsatisfactory, but appears to have little or no advantage over reflex heat

The intermittent venous occlusion apparatus—Lewis and Grant found that the removal of a temporary venous tourniquet caused a temporary increase of blood supply to a limb From this observation has been developed the intermittent venous occlusion method of treatment The apparatus is made in two forms a rather cumbersome but nevertheless effective type, which works off the domestic water supply (Baird and Tatlock, London), which costs about £5, and a more convenient type working off the electric mains, which is however, considerably more expensive The question of cost is

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may be curative if performed sufficiently early; this is contrary to the evidence Certain cases may be helped by sympathectomy; these will, in the main, be those with predominant skin lesions and with a marked spastic element (as determined by vasodilator tests). The decision to operate must be most carefully weighed, and no extravagant hopes held out to the patient

Diagnosis and Treatment of Acute Occlusion of the Limb Circulation

The ætiology of acute occlusion of the limb circulation comes under four headings

(1) Embolism
(2) Thrombosis
(3) Traumatic arterial spasm
(4) The very rare cases of dissecting aneurysm occluding the limb vessels

The common source of *embolism* is from the heart, arising during states of disturbed rhythm (chiefly auricular fibrillation) with coronary infarction, with congestive failure, or from bacterial endocarditis. Paradoxical embolism via a patent interauricular foramen is very rare Emboli may arise from sclerotic blood vessels or from aneurysmal sacs

Thrombosis is less common than embolism, and usually arises [illegible] ession [illegible] ltera- [illegible] of an artery, the spasm may not only involve the artery but also the collateral circulation

[illegible] limb circulation is [illegible] ich may lead to [illegible] Diagnosis of the ætiological factor can often be made without difficulty, but the distinction may be difficult if two predisposing causes exist, i e. auricular fibrillation and arterial disease A precise ætiological diagnosis is not a necessity, except where surgery is required, as a common deleterious mechanism—ischæmia—operates in all cases, and treatment is directed to the alleviation of this factor *The earlier the diagnosis* is made the *more successful* is the treatment

Pain is the most prominent symptom, as emphasised by Lewis, it is due in practically all cases to ischæmia and not due to the pressure of the clot in the artery It is likely that the presence or absence of pain is due to the presence or absence of concomitant spasm, with spasm the limb ischæmia will be greater and appear earlier That pain is not invariable is due to the fact that ischæmia rapidly impairs conductivity in nerves, and if the impairment of nerve conductivity occurs prior to the accumulation of sufficient muscle metabolites, pain will not be perceived, this is quite likely to occur if the limb is resting If the limb is being exercised at the moment of embolism, then pain will be a most prominent feature of

important, as for the best results this treatment must be continued for long periods, and a low-priced apparatus can be used at home.

Controversy still surrounds the effectiveness of this machine, but clinical reports have on the whole been enthusiastic, and a small personal experience is in agreement with this view. The only contra-indication is during the active phase of Buerger's Disease, at which time the local pressure may favour the production of lesions underneath the cuff. Of all mechanical means to increase the circulation, this appears to b[illegible]

Pressures of 30–60 mm [illegible]
on and the same time off. [illegible]
to the treatment, which may be used for long periods (six or more hours). Most patients sleep comfortably with the machine working. The relief from rest pain is often spectacular; skin ulcerations resistant to other forms of treatment often heal, and the "claudication distance" is frequently increased.

Numerous tissue extracts have been employed for their vasodilator properties, most have only transient effects and are worthless. It does appear from a study of the literature that deproteinised pancreatic tissue extract "Depropanex" (Sharpe and Dohne) possesses a distinct therapeutic action. The chief success has been reported with intermittent claudication, it is administered three times weekly by intramuscular injection of 2–4 c c. Protracted periods of treatment (several months) are required

Many vasodilator drugs have been used. With the possible exception of β methylacetylcholine they are apparently useless. β methylacetylcholine may be given by mouth or preferably by iontophoresis, its effect is chiefly on skin lesions.

Control of Infection.—The advent of penicillin has rendered the [illegible] merly. Infections [illegible] ited at once both [illegible] its by continuous intramuscular drip) are required, since the blood supply to the affected part is minimal Ingenuity may be required to maintain a high local concentration of the substance. This drug, if properly employed, will save many damaged limbs

When strepomycin is more readily available its use in penicillin-resistant infections will have to be evaluated. Meanwhile tyrothicin (now available commercially) may be useful applied *locally* in such cases.

Surgery—At times the surgeon may have to be employed to perform an amputation for severe sepsis, an obviously useless limb giving rise to intolerable pain, or to aid the course of nature The attitude towards surgery should be very *conservative*, as remarkable [illegible] management If surgery

Sympathectomy has been recommended for the treatment of Buerger's Disease, certain workers have claimed that this procedure

intravenous injectio Dosage is controlled by de a blood clotting time of 15– lution of 0 9 per cent NaCl with 10 mg of heparin per 100 c c. is frequently employed, and usually a dosage of 1–2 c c per minute will be adequate.

A new approach to the problem of heparin administration has been made by its incorporation in the Pitkin menstruum (18 per cent gelatin, 8 per cent dextrose, 1 per cent acetic acid, water to 100 per cent) The Pitkin menstruum, with or without added vasoconstrictors, releases water-soluble drugs slowly James *et al* (1946) and Loewe *et al* (1946) have shown that a single injection of 300 mg. of heparin incorporated in the Pitkin menstruum will produce an adequate depression of the clotting time for 2–3 days This innovation is a great advance and allows all patients, whether in hospital or not, to receive the benefits of heparin administration This mixture is app be brought bac protamine sulphate

The unaffected portion of the body should be warmed by heat cradle to dilate vessels by reflex heat Morphia should be used in adequate doses to control pain, this reduces stimuli to vasoconstriction. The drug is also an excellent central sedative, and has a local vaso dilator effect on arteries

Alcohol in large doses is a useful vasodilator and soporific and may be administered freely Papaverine has acquired a reputation in the treatment of this disorder and should be given in doses of 60–100 mg by very slow intravenous injection. Such a dose may be repeated in three hours It is seldom necessary to give more than three doses, as if benefit appears it is seen early A further measure that has as yet not been adequately investigated is the removal of sympathetic tone by paravertebral block with procaine or procaine in oil. The injection is technically easy, some 30 c c of solution is required. This procedure is worthy of extended trial as it can do no harm, and may do a considerable amount of good

If after 4–6 hours of such measures, the case is one of embolism, and the circulation is not showing signs of recovery, embolectomy must be considered This operation performed by a competent surgeon may save the limb It is a minor procedure carried out under local anæsthesia It used to be stated that embolectomy after 12 hours was almost useless, with the use of heparin it is obvious that this time can be very considerably extended If traumatic arterial spasm is suspected and the circulation is not recovering, then operation to explore the artery will be required

The place of the "Pavex" boot or of the intermittent venous occlusion apparatus in the treatment of this condition, though advocated by some workers, is not yet proven

the clinical picture. Roughly 70 per cent. of cases experience pain after occlusion of the blood supply.

The next most frequent symptom is a *sensation of numbness*, closely followed by complaints of coldness. Anæsthesia, though extensive, is not complained of by the patient if the limb is stationary, as it will not be perceived unless movements are made. Other patients complain of "pins and needles" sensations, tenderness of the limb, cramps, or itching The acuteness of the symptoms depends to some extent upon the suddenness of the occlusion, the site of the occlusion, and the state of the remaining vessels in the limb.

Examination of the limb will reveal absence of distal pulsation, *decreased temperature of the affected extremity, pallor, but some*times cyanosis, in late cases "Bier's spots" are present, giving a mottled appearance Loss or diminution of reflex is common, muscle power often diminished, sensation loss is of the "glove and stocking" type The site of embolic obstruction may be tender and a mass may be palpable.

Localisation of the embolus is important, chiefly if embolectomy is contemplated, but is also useful from a prognostic viewpoint Palpation of a tender mass in the line of the artery is a most reliable *sign when present, but it will be most often absent Oscillometry* often gives valuable information, as may the absence of pulsation in the line of the artery in which pulsation can be felt proximally. The upper border of low temperature should be ascertained, with occlusion of the popliteal artery it is located just above the ankle, whilst with occlusion of the femoral just above the knee, a similar relative relationship holds good in the upper limb. Observation of the point of loss of the Lewis triple response is also useful; this is tested by drawing a pencil with some force down the longitudinal *axis of the limb, the upper border of normal reaction is just* above the line of temperature impairment.

Treatment.—The objects of treatment are:

(*a*) *To shift or remove the embolus if present.*
(*b*) To reduce the local metabolism of the limb.
(*c*) To encourage the collateral circulation
(*d*) To release any arterial spasm

The limb is kept stationary, horizontal and cool, in order to reduce the local metabolism The degree of cooling should not be excessive as this leads to dangers of damage by cold and a direct constricting action of cold on the vessels, 20°–25° C. is a satisfactory temperature.

Though adequate proof of its help in uncomplicated *cases has not* yet been given, it is advisable to heparinise all persons with arterial occlusion. This measure will help to prevent extension of thrombus formation in a stage of slow blood flow, if embolectomy is required this measure is almost essential. To be used effectively heparin must be given by the intravenous route. Two methods are open, either the administration can be by intermittent injection or by continuous

is only partly relieved by release of the occlusion for a very short period, the finger will show areas of blotchy redness.

The prognosis is very variable. Many otherwise normal persons suffer mild attacks under severe provocation, and never have any further trouble. Mild cases in young persons may clear up completely, whilst many cases remain unchanged for years. A few cases, and these are nearly always women, become progressive or may be very severe at onset. The attacks are very easily provoked and may occur on warm summer days, and the periods of ischæmia may be of great length.

Finally nutritional changes occur, the fingers are tapering and narrow, the nails are curved, ridged and brittle, and X-ray shows the bones to be rarefied. Small areas of necrosis appear at the tips of the fingers and separate slowly and painfully. Trauma is badly borne, and though massive necrosis is infrequent, the fingers gradually become shortened by multiple necrosis.

Although the two conditions are not always associated, many cases of advanced Raynaud's Disease show some degree of scleroderma. The severity of the Raynaud's Disease is not the primary factor, as some cases are entirely free, whilst some cases of scleroderma have not, as far as is known, ever had Raynaud's Disease, whilst the reason is not known the relationship between the two conditions is undoubted. The skin becomes increasingly hard, tense, shiny and pigmented. *It is not possible to lift the skin, whilst increased bulk* of the tissue may render the tapered finger of Raynaud's Disease bulbous. The underlying fibrosis may have serious effects on the mobility of joints covered by the affected skin, especially in the fingers, leading to severe crippling. The affection is often diffuse, involving fingers, hand, face and, less often, the arms, chest, or thighs.

Pneumatic-hammer disease.—The introduction of pneumatic vibrating machines into industry was followed by the appearance of a disease similar in many ways but differing from Raynaud's Disease. The condition is entirely local, confined to one hand (that subject to the greater vibration being affected). Where the part to be machined is held in place by hand, it is the supporting hand rather than the hammer hand which is affected. Any type of tool operating by percussion may cause the disease, which is also seen in those operating heavy machinery such as pneumatic road drills. A further factor in many cases is that the hands are exposed to a cold draught of air from the machine's exhaust. The affected fingers show, either in response to cold or to using the machine, very pronounced pallor accompanied by a "pins and needles" sensation and anæsthesia, as in Raynaud's Disease. With the termination of the attack the change from a cadaveric pallor to a cherry-red colour is rapid.

Gurdjian and Walker (1945) have reviewed this condition and

Functional Arterial Disease

The term Raynaud's Phenomena is more satisfactory than Raynaud's Disease, as the typical changes are of multiple ætiology Temporary occlusion of the smaller arteries leads to changes in the fingers (or toes) which are diagnostic, the most important provocative agent is cold, but other factors, such as emotion, play an important aggravating rôle

The pathological basis for this deviation from the normal (quantitative rather than qualitative) is not satisfactorily explained. Conceptions of the disease process have ranged from a functional disorder of the sympathetic system, an organic disease of the sympathetic system, to actual arterial disease. The alleged organic changes in the sympathetic ganglia have not as yet been confirmed, whilst Lewis (1936) has produced very strong evidence against regarding the condition as being merely a functional disease of the sympathetic system. This worker showed that in some cases, at least, the vessels themselves were abnormal Arterial changes are undoubtedly present in long-standing cases, but many authorities believe these changes to be secondary to long-continued periods of occlusion.

It is likely that the digital vessels themselves are abnormal in the sense that they react more violently then do those of normal persons to the stimulus of cold, that excessive response of the sympathetic system plays a part of variable importance, and that the vessels

the

nt

incidence in the female. These figures have not been accepted by other workers, who think that 70 per cent. is nearer the truth There is some evidence of a familial link, the tall spare person is more likely to be affected

The *initial manifestations of* the attacks may be unnoticed by the patient The usual features are pallor and slight cyanosis. As the attack progresses the skin becomes blanched and appears waxy. If the fingers have been previously highly coloured, cyanosis may be present; a reflux from the veins into the dilated vessels may occur. Thus either a waxy blanched appearance or deep cyanosis indicates profound stasis *of* blood flow due to occlusion of the digital arteries. If the patient remains exposed, tl

numb and cool to the tempe

aching pain may then develop.

at onset, very frequently becomes bilateral.

The *phase of recovery is signalled* by the appearance of a red flush which advances from the base This flush is due to reactive hyperæmia. If the attack has been long continued the patient may complain of a disagreeable tingling, as the circulation returns The attack may be abated at any stage The length of attack is variable, between 5–30 minutes is a typical period, but in advanced cases circulatory arrest may be present for hours at a time. *If the attack*

decrease of the width of the palpebral fissure and contraction of the pupil Occasionally a neuritis from scar tissue may leave the patient worse off than before. The type of case in which operation is considered is either a patient in whom evidence of progression is found, or one in whom long repeated periods of ischæmia are present. Vasodilator tests may help the decision.

Acrocyanosis—The term acrocyanosis is applied to a condition in which the extremities become abnormally blue in response to cold The blueness is not always uniform as red or white spots may be present On occasion œdema may be associated The condition is unsightly but not serious The ætiological concept that best fits the facts is to regard the cyanosis as secondary to arteriolar constriction If histamine is pricked into the skin a brilliant red flare results T[illegible]

I[illegible]

n[illegible]

efficacious However, the indications for such an extensive procedure are scarcely ever present

Erythromelalgia—Erythromelalgia is a syndrome of mixed and uncertain ætiology, for which many alternative names have been suggested The essential abnormality lies in the skin, which exhibits an acute sensitivity to stimuli, which normally produce no pain response The condition is seen clinically as a syndrome of pain and redness in the skin induced by a temperature which is borne by normal persons without distress The pain is described as "burning" Mitchell's original description of it as the pain of intense sunburn was apt. Lewis has shown that the skin exhibits a marked reaction to other stimuli not normally effective, and has demonstrated that normal skin, if suitably traumatised will show similar reactions

The usual complaint is of pain in the ball of the foot or the toes The condition is greatly aggravated by venous obstruction or dependency of the part and is relieved by cold However, if the cooling is continued, a further "critical" temperature is found which results in a similar type of pain Unilateral or bilateral forms are seen Walking is a particular source of worry, as not only do the feet become warm in the dependent positions but friction acts as a severe intensifying factor The affected skin is red and very tender, it may be warm or cold, depending upon the "critical" temperature

The diagnosis is made by the finding of a constant critical temperature

Treatment is difficult and often ineffective Analgesics should be prescribed, of these, aspirin in small doses often has a remarkable effect, relieving the pain for a period of days In view of the present ætiological conception the trial of a course of histamine azoprotein would be worth while, also the newly discovered benadryl may have some beneficial effect

to several years. The condition tends to be mild and not progressive. Removal from the offending work does not produce a cure, but some minor alleviation of symptoms often results. The prevention of this disability depends on elimination of vibration to the hands by providing the machines with holders and stands.

Organic disease.—Organic disease of an artery wall (thrombo-angiitis obliterans, etc.) may at times in its early stages mimic Raynaud's Disease. In cases where genuine doubt exists a period of observation will make the diagnosis clear.

Treatment

Where a specific causation is known, as in pneumatic-hammer disease, the patient must be removed from this occupation. Since the ætiology of Raynaud's phenomena is in many cases unknown treatment must be directed towards minimising the results. Periods of repeated ischæmia, besides being annoying to the patient, are also a source of danger to the nutrition of the affected tissues, and must as far as possible be prevented.

Certain cases where the manifestations are very mild require no treatment. The most important provocative factor is cold, and local cold is much more likely to produce a paroxysm than general cold. The patient should always be warmly clad, with particular reference to the extremities and fingers. Long-sleeved woollen vest, warm long-sleeved dresses, warm stockings and stout shoes should be worn. *The hands should be protected by fur-lined gloves in cold* weather, and a thinner type of glove in hotter seasons. Care must be taken as to the temperature of the water in which the hands are placed.

Ionisation with β methylacetylcholine has been favourably reported upon, it is said to decrease the frequency and severity of attacks. A better way, if this can be managed, is residence in a warm climate.

Areas of necrosis should be treated conservatively, as, though the pain is often grea

The question advised is a difficult one ogy of the condition, the ultimate basis of such a decision must rest upon the proven results of such treatme reported in the literature are been grossly inadequate. Ma not be of sufficient severity to require operation, and can be satisfactorily *treated by medical means*. In selected cases sympathectomy often proves a beneficial procedure, though, since the vessels later become sensitised to circulatory vasoconstrictor substances, the initial results of sympathectomy are not maintained.

Though the results of early operation are better than those of late operation, certain criteria of severity must be set, as otherwise many very mild cases will be unthinkingly submitted to this procedure. The unilateral cervical operation may prove unsightly owing to the

Diagnosis.—Early diagnosis is vital, as it is only in the early stages, when the clot has an insecure attachment to the vein, that embolism is likely. By the time that marked tenderness and a palpable mass can be felt along the line of the vein, the danger of embolism from that portion of the vein is almost *nil* If thrombophlebitis has been established in one leg for 3–5 days and the patient dies of pulmonary embolism, then at post-mortem it will often be found that the embolus came from the *other leg.* Approximately 85 per cent. of venous thromboses have their origin in the *deep veins* of the calf

It is unfortunate that at a time when diagnosis is most important the symptoms and signs are often minimal Any patient confined to bed or becoming ambulatory, and who makes any complaint referable to legs or chest must have the legs examined thoroughly. If doubt still exists venography may give additional information Where deep thrombophlebitis cannot be excluded, treatment should commence

The *signs of thrombophlebitis* are

(1) Pain or tenderness in the sole of the foot, ankle, or most frequently the calf
(2) Pain on forced dorsiflexion of the foot
(3) Fullness of the superficial veins
(4) Low pyrexia
(5) Increased local temperature.
(6) Local œdema.
(7) Induration
(8) Slight cyanosis

[illegible] e absent, but if [illegible] cases [illegible] rkers have employed X-ray visualisation of the deep venous system by means of contrast agents as an aid to diagnosis This work was summarised by Bauer (1940) and since that time several papers have appeared in the American literature

A final evaluation of this procedure is not yet possible The technique is simple. the heel is elevated six inches, and the contrast agent (20 c c. 35 per cent diodrast) either injected into a vein on the foot, or into a small constantly present vein one inch behind the external malleolus, which is exposed by incision The injection takes one minute It is an advantage to use large plates so as to visualise the femoral vein The vein is then washed through with normal saline It would appear helpful to combine this examination with a preliminary determination of the venous pressure of the limb This direct determination, if substantially raised, would be diagnostic, the other leg or the technically easier arm veins could be used as a control

The normal venogram shows the deep veins of the calf, the popliteal and femoral veins, and a few superficial tributaries The deep pattern varies considerably in different persons, usually two

Sudeck's Atrophy

The rare Sudeck's atrophy first described in 1900 deser mention. The condition is not well defined but the usual picture that of an injury, which may be trivial or severe, causing the format of a focus of irritation, which initiates a reflex disturbance circulation The disturbance of circulation may persist when focus of irritation disappears Persistent burning pain at the site injury is complained of and the temperature of the involved extrem is found to be higher than that of the opposite side. A periarticu œdema appears which gradually spreads to involve other tissu The joint movements become limited by fibrosis and spastic muscl Atrophic changes become severe and later a patchy osteoporosis visualised by X-ray Finally the circulation of the affected extremi is lessened.

Miller and Tahets (1942) have published some interesting work this subject. They stress the importance of the control of pa during all phases of surgical treatment, and thus the prevention foci or irritation In their hands surgical removal of such foci h been followed by alleviation if this procedure is performed early.

Acute Thrombophlebitis (Phlebothrombosis)

Of recent years the increasingly accurate diagnosis of pulmona embolism has shown its great frequency, and stimulated much intere in the diagnosis and treatment of the prime causative factor thrombosis of the leg veins. Similarly improved follow-up h shown that marked disability may occur in the affected limb, as t result of extensive thrombosis

That the time is ripe for reorientation of certain traditional vie is shown by Swedish practice. Jorpes states that as a result of t keen interest now taken in deep vein thrombosis, the use of ven graphy as an aid to diagnosis, and the use of heparin in treatmen pulmonary embolism is now a practically extinct disease in Swede Bauer (1946) has published an extremely interesting review of th work

The ætiological factors responsible for the common type thrombophlebitis following operation, or the confinement of o persons or cardiac cases to bed, are to some extent obscure Certa factors are known which favour thrombus formation· (1) reduce blood flow, (2) dehydration, (3) injury or inflammatory change the vein; (4) blood changes.

Prophylaxis consists of (1) mobilisation of extremities, (2) t maintenance of adequate hydration, (3) breathing exercises, (prevention of increased intra-abdominal pressure by tight binder restricted position, etc , (5) anticoagulant therapy where indicate (6) the avoidance of unnecessary confinement to bed.

Though often regarded as a surgical complication, pulmonar embolism is more frequently seen in the medical wards, and is ofte a terminal event.

shown this measure to be remarkably effective especially in the prevention of pulmonary embolism It is satisfactory to note that they believe that, despite the great expense, this measure can be justified on economic grounds, since so much hospital time is saved The administration should be continued for five days or longer. It is as yet uncertain whether heparin is the entire answer to the thrombophlebitis problem (type (*a*) case) but there is no doubt that its use marks a great advance

Vein ligation is a controversial therapeutic step The exponents of this procedure state that besides rendering pulmonary embolism almost impossible, the ligation improves the general circulation by cutting off impulses giving rise to spasm Fine, Frank and Starr (1942) have performed many vein ligations Initially they considered that the femoral vein should be ligated below the origin of the profunda branch, this gave rise to no disability However, certain of their cases then experienced embolism via the profunda branch, and they now feel that ligation above the profunda branch is the site of choice They state that ligation at this site gives rise to only
Before
adminis
whether the author's statements are correct It would appear that if heparin is not available the simple operation of femoral vein ligation should be seriously considered in all cases

Rest of the limb is frequently recommended in order to obviate breaking off of thrombus It does not seem that in practice mobilisation is so dangerous a step as it would appear to be in theory Exercise pla and by this means may retard lern tendency is to allow exerci heparin is used it seems reasonable to start leg exercises 3-4 days after the diagnosis has been made, and to get the patient up inside a week provided no obvious contra-indication exists If vein ligation has been performed, mobilisation (with supporting stocking if required) should be rapid

With cases in which the limb circulation is seriously disturbed (type *b*) it has been suggested that the cause lies in the affected portion of the vein (considerable reaction in diseased segment) The diseased vein is believed to give rise to impulses which, travelling to the cord, cause vasoconstrictor impulses to both arteries and veins, the efferent pathway being the sympathetic system Ochsner and de Bakey (1940) have suggested that paravertebral procaine block of the sympathetic system will cut the vicious circle of thrombosis — deficient circulation — further thrombosis — increasingly deficient circulation They claim excellent clinical results, and this treatment merits extensive trial in this type of case, where the circulation of the leg may be seriously impaired

main trunks form the popliteal. Difficulty is sometimes experienced in differentiating organic block and venospasm. It seems from a study of the published work, and the excellent results obtained in Sweden, *that despite the difficulties of interpretation this technique* marks a real advance

The question as to whether diodrast can by itself produce venous thrombosis is important; so far one case has been reported where this sequence is likely However, the risk is certainly very small, and chemical thrombophlebitis very rarely gives rise to trouble, as the clot is most firmly attached to the vein.

Treatment.—Recently several methods of treatment have been advocated, all are probably advances on current practice, it being difficult to decide which approach will yield the best results.

Studies of limb circulation have revealed that the situation in thrombophlebitis is not merely one of venous obstruction. Veal and Hussay (1942) in an excellent paper state the matter as follows: "We wish to emphasise that the prime consideration in acute thrombophlebitis is not recognition of the fact that a clot has formed in the vein, but the fact that all elements of the circulation in the affected extremity are altered as a result of the venous occlusion."

There is evidence that both arterial and venous spasm is present with concomitant lymphatic *slowing*. These factors reduce blood flow and further the propagation of the thrombus If these factors are allowed to persist, not only will severe damage be done to the limb, but the possibility of embolism will be increased

For the purpose of treatment it is helpful to classify the cases into two types:

Type (*a*), the commoner, seen after operations, little reaction in vein wall, insecure clot fixation, a dangerous source of embolism, *very little disturbance of limb circulation.*

Type (*b*), typically seen in the puerperium, the "milk leg," considerable venous reaction, secure clot fixation, little risk of embolism, easily diagnosable, profound disturbance of limb circulation.

Treatment is directed *towards three indications, the importance* of each indication varying according to the type of case:

(1) The prevention of further thrombus spread.
(2) The prevention of pulmonary embolism.
(3) The restoration of normal limb circulation.

The prevention of further thrombus spread is dependent upon two main factors. (*a*) decreasing the coagulability of the blood, (*b*) the restoration of a rapid blood flow.

Heparin is the most useful and safe anticoagulant in existence, its powers of inhibiting platelet deposition are unrivalled. Despite the disadvantages of expense, the necessity for intravenous adminis-[illegible] is required heparin [illegible] tiveness. [illegible] adminis-tration described under arterial embolism). [illegible] ence has

CHAPTER XXXV

PHYSICAL THERAPY

Physiotherapy

MANY of the chapters in this book contain suggestions as to the most suitable type of physical therapy for the particular disorder.

In this chapter the problems which physiotherapy can solve will be considered, and descriptions will be given of the methods available. Indications for treatment will also be considered.

The Problems which Physiotherapy may solve

It must be stated quite plainly that locomotor disorders cannot, in the majority of instances, be adequately treated without physical methods In the past these methods have sometimes been associated with people of doubtful repute and because of this the whole subject has suffered Every doctor should have a sound knowledge of physical methods, but to the specialist in locomotor disorders an intimate and detailed knowledge is essential, and he should be prepared to supervise and advise on treatment at every stage

Physiotherapy proper can aid only in the solution of certain problems. The primary action of physiotherapy is through the skin, and Leonard Hill (1938) has discussed how this may occur Just as a radio-receiver [illegible]
other sources of [illegible]
final energy is [illegible]
supplied by heat rays, ultra-violet rays and X-rays is augmented by chemical charges in living cells The initial energy only is transferred to the cell by means of absorption and interaction of radiation with matter Radiation may produce ionisation in living matter, then chemical changes and then biological alterations On these suggestions it seems clear that to produce the changes the initial energy must be supplied and at a certain intensity As an example of how the skin may become sensitised Hill quotes the case of the congenital hæmatoporphyrinuric whose skin becomes so sensitive to light that brief exposure to sunlight leads to necrosis As more knowledge of the effect of physiotherapy becomes available, the indications and contra-indications will become better defined

At the present time it seems probable that the following are the principal known effects of physiotherapy An increase of tissue metabolism occurs, presumably both anabolic and katabolic The blood supply is increased and the venous return hastened In the case of massage the venous return is principally affected The lymph flow is also accelerated In the case of faradism the muscle metabolism is greatly enhanced The skin erythema produced is probably due to the release of a histamine-like substance acting on the vessels

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Fig 252

Effleurage of Thigh

The hands are shown in process of making a long upward sweep towards the inguinal lymph glands This manœuvre is carried out before the leg and foot are treated



Fig 253

Effleurage of Fingers

Pressure is applied laterally and anteroposteriorly to the fingers from the tips to the metacarpophalangeal joints

The whole effect will be felt in the tissue-spaces, where raised metabolism, increased vascular and lymph flow will enable tissue respiration to proceed apace. Diapedesis of leucocytes to the part treated and phagocytosis is also likely. Ultra-violet light converts ergosterol into vitamin D, and so calcium and phosphorus metabolism will be aided. The direct *galvanic current may lead to movement of* ions locally, and various substances may be ionised extradermally and be absorbed. As the result of all these changes, absorption of products may occur from the skin, leading perhaps to a mild protein shock effect, such as is obtained in autohæmotherapy.

From this short summary it seems possible that physiotherapy may be of assistance in several types of pathological change. In all cases where tissue or muscular metabolism is low, where vascular or lymph flow is impeded and venous return poor. In all cases, therefore, where chronic infection may play a part, especially those in which the blood flow is small and the leucocytes are not passing through the walls of the vessels In cases where small-celled infiltration has occurred, and where a stagnant anoxemia plays a part In some *cases where pain is a prominent symptom* by decreasing local swelling Sometimes in cases of allergy. It has been said, with some degree of truth, that the skin is the largest endocrine organ in the body and some think that a proportion of the benefit that physiotherapy confers depends on the stimulation of this organ

It will not do good in cases where established fibrosis and ankylosis have proceeded so far that the condition has become a mechanical disability, and it can do harm in all cases of malignant disease and in some cases of tuberculosis. X-rays and radium, although true physical therapy agents, are excluded from this generalisation. This leaves a range of usefulness which is very wide indeed

Massage is usually divided into three particular movements, but naturally th

Effleurag l out towards the heart i e the thigh or arm, is t . the leg and foot or forearm and hand. The idea behind this is that the vessels and lymphatics in the proximal part are so to speak "cleared" before the distal part is massaged. Its effect is to soothe and relieve pain, and enliven *the circulation so that inflammatory* and waste products may be removed. It is the only permissible form of massage in acute arthritis It is used principally in cases of local œdema, circulatory disturbances, in neuralgia, and as a prelude to other types.

Petrissage includes such things as deep kneading, picking up muscles and compressing them in a centripetal direction, and deep friction usually in a circular direction. It produces *a reflex* vaso-dilation in the deep structures and is used to disperse fibrous nodules and relieve areas of myospasm. It also aids the deep circulation *Panniculitis* massage lies half-way between effleurage (deep) and petrissage In cases where panniculitis is present, and multiple

Heat should not be used in cases of neuralgia as it makes the condition worse. This applies particularly to idiopathic sciatica and brachial neuralgia where none of the known ætiological syndromes can be found Even with considerable experience it is not possible always to foretell the cases in which heat will help, but if heat makes the condition worse, it should be stopped immediately. Methods of applying dry heat include the infra-red tunnel. This was devised

ent alone is best treated at home.
od source of long-wave infra-red rays, and so is the more modern electric fire of the shorter infra-red rays. It is quite a good plan in these cases to apply "Iodex" and to allow the patient to sit in front of the fire for twenty minutes.

Deep heat can be supplied either by the conventional diathermy apparatus or by the short-wave method

Diathermy is a very high frequency current and on account of this all unpleasant side effects are eliminated except the production of heat The rate of frequency varies in different machines from 500,000 to 10,000,000 cycles per second The maximum heat effect lies half-way between the two electrodes If suitable arrangements are made most joints can be treated, so that the maximum heat is in the joint itself The physician should satisfy himself that this is done

Short-wave diathermy has probably come to stay As the wave-length used in this apparatus is a near relation to the wireless wave, it does away with the difficult problem of surface heating which is so troublesome in conventional diathermy In spite of this obvious advantage, it is doubtful whether it will eventually occupy the same position that is now accorded to it

Diathermy of either variety holds its own in the physical medicine field for two reasons It has no place in acute conditions (of locomotor origin) or in neuritic conditions, or in peripheral vascular disorders. In medical diseases of bone it is a positive menace But in chronic joint diseases like osteoarthritis of the knees or hips it may be the treatment of choice Intensive conventional diathermy is probably the only treatment which may relieve osteoarthritis of the hips for a considerable period The second indication may be certain conditions like the so-called menopausal arthrosis of the knees in which an endocrine origin is possible Under these circumstances pelvic or rectal diathermy with a vaginal or rectal electrode and an abdominal belt electrode may be useful There is a great tendency amongst physiotherapists to use electrodes covered with soaked lint This is probably a mistake, and it has always seemed that for conventional diathermy bare electrodes carefully moulded to the part allow a greater current to pass There is no need for "contact paste," but care must be taken that burns are not caused. Some physicians use this method in shoulder lesions but little good seems to come of it, nor is the treatment helpful in rheumatoid arthritis If dry heat fails, moist heat may be tried.

adhesions form *in the skin*, the skin is picked up, and squeezed and then friction is applied It is a painful but useful form of massage

Tapotement consists of rapid percussion with the sides of the hand Where such a treatment is indicated it is usually best to employ a vibrator. It is really a form of microtrauma and is used



FIG 254

Skin rolling (or Panniculitis Massage)

in cases where petrissage cannot produce a deep enough effect. If given *very lightly* it produces an analgesic effect but must not be long continued Its use except for this is rather problematical

Pointers about Massage

1 Use superficial effleurage *only* in cases of acute arthritis.

2 *Do not allow a course of massage to continue indefinitely*. It suits some temperaments extremely well and may in the course of time sap all personal initiative from the patient.

3 Always combine (where possible) massage with voluntary active movements, except in very acute cases

4. If massage is acutely painful, suspect your diagnosis, your physiotherapist, or the presence of peripheral neuritis.

5. It is important that the hand of the masseuse should be accurately moulded to the part massaged, but bony points should be avoided.

Heat and its Relationship to Massage

These two measures are, to a large extent, complementary, and it is probably true to say that their union more than doubles their efficiency. *Infra-red rays* or *radiant heat* have the effect already described, but it is of a very superficial character, and in excessive doses may affect vessels, so that they lose their power of constriction. To overcome this difficulty it is wise at some stages to omit the heat, *in spite of its advantages*.

Heat should not be used in cases of neuralgia as it makes the condition worse This applies particularly to idiopathic sciatica and brachial neuralgia where none of the known ætiological syndromes can be found. Even with considerable experience it is not possible always to foretell the cases in which heat will help, but if heat makes the condition worse, it should be stopped immediately Methods of applying dry heat include the infra-red tunnel This was devised originally as a sweating mechanism

A case which appears to need heat alone is best treated at home. The old-fashioned hot brick is a good source of long-wave infra-red rays, and so is the more modern electric fire of the shorter infra-red rays It is quite a good plan in these cases to apply "Iodex" and to allow the patient to sit in front of the fire for twenty minutes

Deep heat can be supplied either by the conventional diathermy apparatus or by the short-wave method

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Application of Moist Heat

There are innumerable methods of applying moist heat.

The application of kaolin and glycerine or antiphlogistine is the simplest and adequate for all ordinary purposes, as also are bread and linseed poultices. *Paraffin wax* can also be used at home. Special wax with a low melting-point can be obtained. The wax is heated in a saucepan until it melts. At this stage it is painted on to the affected part with a brush and allowed to set. Seven or eight coats are used The part is then wrapped up to keep in the heat It should be left on about an hour, when it can be peeled off and an erythema will remain As an alternative, hands or feet can be immersed entirely

Wilde's Bath is a steam bath It needs special apparatus but in cases of gout the results are excellent.

Hot baths are also exceedingly useful, especially in cases of fibrositis

Small vapour cabinets will soon be available again. The Cox-Cavendish Company have an excellent one which can be used with an ordinary chair and is extremely portable. Gout and fibrositis both benefit, but great care must be taken not to treat cases of vascular disorder in this fashion. Rheumatoid arthritis does not benefit but sometimes sciatica does.

One special method of applying moist heat to the arms and legs is by means of the Bertholett Cabinet. The cabinet is filled with steam and the arms and legs are inserted, as shown in Fig. 256

Mud packs can be obtained at most spas and before the war could be used at home. Some private physiotherapists carry stocks. The mud is applied to the affected part for ten minutes at a temperature of 108°. The time and temperature are gradually increased. The treatment is good for sciatica, osteoarthritis and some cases of rheumatoid arthritis It is especially useful for shoulder lesions.

The Therapeutic Pool is a very useful measure, as is all balneotherapy for movements of joints and re-education of muscles. The support of the water takes the weight off the limbs and makes them buoyant so that free exercises can be taken and muscular spasm relaxed It is of special value in osteoarthritis of the spine and hips.

Contrast douches are useful, especially where a vascular component is suspected. Two hoses are used, one with hot and one with cold water. The hot jet at 105° F is kept on for six minutes and the cold at 70° F. for four minutes

Spray massage consists of lying on a slab with water being sprayed whilst the whole body is massaged. The treatment is unsuitable for rheumatoid arthritis or for patients with arteriosclerosis. It does good in obese cases with osteoarthritis These cases also do well with *Foam Baths*. The foam covers the whole body so that the patient's temperature rises rapidly. It can be followed by massage and is useful for osteoarthritis and patients who are rapidly putting on weight.

All these methods have the same basic pattern of reaction and



FIG 255

To show the application of paraffin wax to a hand Several coats are applied and the hand is then wrapped in cotton wool

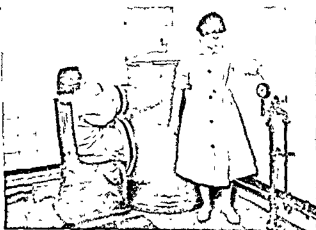


FIG 256

The Bertholett Cabinet (see p 596)



Fig 257

Showing the application of a mud pack to the knee. Note that the pack must do more than merely cover the knee, it must extend both above and below the joint.

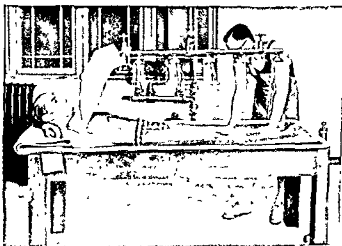


Fig. 258

Spray massage

Figs 255–258 are taken by permission from *Hydrotherapy*, by R M Le Quesne and M Granville Cassell & Co, Ltd, London (1936)

seem to relieve symptoms. Most are better combined with a spa régime.

Electrical Methods

Galvanism is an ordinary continuous one-way current If interrupted it causes muscle contraction It can be produced by a small portable case with dry cells or from the mains by special apparatus Of the two poles, the anode (or positive) is soothing and the kathode (or negative) stimulating

Anodal galvanism always seems to be one of the most useful methods in physical medicine Apparently it has some kind of decongestive effect for it is a great reliever of pain, especially in cases of neuralgia A large pad should be used and a very small current In the case of the hands and feet, small insulated baths filled with water may be used The polarity of the baths is arranged by switches, but in cases of pain with or without œdema the *positive pole* must be used A small tin electrode is dropped into each bath

used for re-educating muscles and for the treatment of the muscle wasting seen in rheumatoid arthritis *Circulatory difficulties* are sometimes helped by the sinusoidal current The faradic and sinusoidal currents should not be used to replace active movements Anodal galvanism is very useful in sciatica and is one of the few things that help in osteoarthritis of the hands, especially the rather
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In
th
at all

The galvanic current can also be used in the treatment known as *ionisation* The continuous one-way current is used after the pads covering the electrodes have been soaked in certain ionisable substances The fact that the ions migrate whilst under the influence of the current makes it possible to introduce substances into the skin The substance used must be put under the correct pole for instance, the negative or kathode is used for iodine and the positive or anode for histamine

Ionisation does well in non-traumatic osteoarthritis of the knees, if used with iodine and sodium salicylate, but the method is limited by the resistance in the tissues, the reaction with the tissues to form non-ionic compounds, and the fact that the ions are carried away by the blood stream

Some authors have a very high opinion of histamine ionisation as a vasodilator It produces urticaria at the site of application which lasts for some time *Acupuncture*.—A sensitive spot is localised by a subfaradic test, a local anæsthetic is injected, and then a long needle is inserted into the sensitive spot The needle is attached to the negative of a galvanic apparatus and is insulated

except for its terminal one-eighth of an inch. A current of three milliamperes is passed for two minutes. Sometimes the needle is used without the current. The treatment is advocated for sciatica in those cases where the nerve is thickened and tender, and for cases of fibrositis

Faradism

This is an induced current and flows intermittently, and only for very short periods of time It is usually "surged," e g. it is gradually raised in value and then gradually decreased, so that the muscular contractions to which it gives rise can build up and then pass to a period of rest It should be used in cases of muscle-wasting and loss of tone as a preliminary to active and supported active movements, but it is a great mistake to "flog" a tired muscle with faradism, especially if the muscle-wasting is due to arthritic involvement. This merely makes matters worse.



FIG 259

Faradic foot baths in the treatment of flat feet The electrodes are here applied for stimulation of the longitudinal arch. One electrode is applied to the motor point of tibialis anterior, the other beneath the metatarsal arch



FIG 260

For comparison with *Fig* 259 In this case the electrodes are placed below the metatarsal arch and the heel in order to stimulate the intrinsic muscles of the foot.

It is very useful in effusions of the knee joint, especially if due to a synovitis of unknown or traumatic origin In this case it is

to selected groups of muscles It is particularly indicated when the back is being treated as the large groups of muscle respond very well If time is not allowed for the muscles to relax between each "surge," fatigue will set in, and the best results will not be obtained

Labile faradism consists of one fixed electrode the other being in the form of a roller, and this is rolled up and down the body It is used a great deal in osteoarthritis of the spine If the pain is not being caused by encroachment of osteophytes into the intervertebral foramina, labile faradism will almost entirely relieve the symptoms This is perhaps one of the most successful applications of physiotherapy.

Heliotherapy

Ultra-violet radiation is produced for use in medicine either by means of the mercury vapour arc, the general carbon arc (the carbons sometimes have cores of a different material), and for local action by the Kromayer lamp

It seems likely that ultra-violet light has a general regulating effect on the metabolism of the body, and that its undoubted tonic value does not entirely depend on its power of converting ergosterol into vitamin D. In addition to this it probably has a side-action on calcium metabolism It is possible that this action is additional to the action of the vitamin D on the absorption of calcium and phosphorus The stimulation of the skin, and the possibility that some immune processes may be influenced *thereby*, is *coupled with* a suggestion that reflex stimulation of viscera may occur from stimulation of the trophic fibres of cutaneous nerves We cannot for the moment be sure whether either or both these suggestions are likely or even possible

The Use of General Ultra-violet Light

Successive areas of the body are exposed to the light both back and front, and the time of exposure is gradually increased. The effect of this is tonic The treatment appears to have its best effect in rheumatoid arthritis, sometimes coupled with superficial massage There is a good deal of clinical evidence that it enhances the value of gold injections, and the fear that it will lead to the deposition of gold in the skin and consequent staining is quite groundless In cases associated with secondary anæmia ultra-violet light is particularly valuable

Some patients buy ultra-violet lamps and use them at home. On one or two occasions patients have been seen in consultation with weird and incomprehensible syndromes attributable to over-dosage

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Fig. 260

For comparison with Fig. 259 In this case the electrodes are placed below the metatarsal arch *and* the heel in order to stimulate the intrinsic muscles of the foot

red rays. It is as well to remember that permanent pigmentation of the skin may remain.

The **Kromayer lamp** gives the same type of radiation as the mercury vapour lamp, but it is a tiny water-cooled burner which can be lifted off the main machine The "face" of the lamp may be used by passing it up and down over a selected area of the skin The effect of the radiation can be increased by pressing the lamp surface hard on to the skin so as to press out the blood from the vessels If held steady in one place either "erythema" or "sub-erythema" doses can be given It exerts a counter-irritant effect and gives rise to reflex dilatation of the deep vessels and so relieves pain locally It is very useful in fibrositis or in local areas of pain round arthritic joints The troublesome "heel-pain" that some patients complain of can be relieved by one treatment If an "erythema" dose is decided upon, the part must be covered with elastoplast If moved up and down the paraspinal muscles it is generally referred to as "Kromayer massage" and is probably the treatment of choice in ankylosing spondylitis after deep X-rays (Fig 261)

Colonic Therapy

A good many of the syndromes which compose the field of locomotor disorders, and particularly those which make up the rheumatic side of that field, are associated with patients of an obese, lethargic and, in women, menopausal type Although not capable of absolute proof, clinical evidence seems to show that these patients either have an unusual bowel flora, or that they absorb toxic intermediate products of protein metabolism more easily than the healthy person. The obesity and lethargy are often associated with a muddy, sallow skin and a somewhat indolent mind It is true that some part of this make-up can be bettered by increasing the rate of tissue-metabolism, but this will not necessarily be effective unless the rate of excretion keeps up

For this reason mechanical means must sometimes be used, but the precaution must be taken that such means do not come to be relied upon to the extent that personal initiative and energy are damped A term must therefore be set on the duration and extent of the treatment

The only method of emptying the bowel mechanically which relies to some extent on the patient's own effort is the "Studa Chair" treatment, and this is the treatment of choice The best method of prescribing this is to give three treatments spread over fourteen days and then stop In suitable cases the results are excellent, as is only to be expected, but control of treatment must lie in the hands of the physician. The treatment involves a good deal of muscular effort on the part of the patient and should not be used for those of asthenic type or with marked vascular degeneration

Hyperpyrexia

This form of treatment is usually carried out by means of the *Kettering Hypertherm* or similar apparatus It consists of raising

with ultra-violet ray, and which cleared up when the exposures ceased, so that it may be as well to discourage the purchase of these lamps for home use If the tonic effect only is required, a general carbon-arc lamp is to be preferred, its effect is more gentle, and some heat is also evolved.

Blister Doses

Eidinow (1938) devised a method of giving intensive doses of ultra-violet rays which led to erythema and blistering of the surface



Fig 261

Kromayer Paravertebral Massage

The dark areas show the erythema resulting from an intensive application of the Kromayer face. Particularly useful in ankylosing spondylitis.

treated This treatment is rather drastic, and personal experience is limited to cases of chronic and long-continued pain without physical signs In these cases the method may succeed where all else fails.

The skin is immediately covered with elastoplast, and this is absolutely essential, or the patient may complain of the most distressing symptoms and retire to bed The elastoplast is left *in situ* for a fortnight and is taken off by the doctor. The skin sometimes comes off with it, and the part should be treated with infra-

the cases which come to the physician are unsuitable for manipulation and the following groups are entirely unsuitable

(1) Spinal senile osteoporosis
(2) Any form of malignant disease, and arthritis of gonococcal or syphilitic origin
(3) [illegible]
(4) [illegible]
(5) [illegible] has not entirely been ruled out
(6) Some cases of osteoarthritis of the spine, especially those with radicular pain
(7) Cases in which decalcification of bone is a very marked feature.

A raised sedimentation rate is said by some to be a contra-indication This unqualified statement is probably not true, but a raised rate should certainly be regarded with suspicion, and as one strong point against manipulation It is not, however, decisive by itself

The two conditions which, more than any others, render manipulation nugatory are the formation of osteophytes and the contraction of soft tissues, usually tendons Osteophytes can usually be visualised on the X-ray if several views are taken and should not take anyone by surprise The contraction of soft tissues is another matter, as it is not always possible to be sure whether restriction of movement in a joint is due to this factor or to intra-articular or extra-articular adhesions This is a matter which frequently comes to the physician's notice, as the commonest type of case he sees is the flexion deformity of the knees which remains when a case of rheumatoid arthritis has either been rendered symptom-free or has burnt itself out If the texture of the bones is sufficiently solid to make a manipulation possible, the question of where the cause of the restricted movement lies must be decided

The physician manipulates only three sets of joints with any frequency, and it is proposed to describe the manipulation of the spine, the shoulders and the knees

Before undertaking any work of this kind it is well to watch an expert at work for some time, and even then to go very slowly at first The point to remember above all others is that mere strength and brute force will accomplish nothing but trauma, the bones and joints must be carefully set at the correct angles and then a little movement at the correct time will provide a sufficient *vis a tergo*

Landmarks *for manipulation* are important A very simple and apparently adequate way of finding out the approximate spinal level is to take the following as landmarks

Spine of scapula—D3–4 spines
Inferior angle of scapula—D7–8 spines
Highest point of iliac crest—L3–4 spines.
Posterior superior iliac spine—S3 spine

The *spinal cord* ends at L1, and the *spinal theca* ends at S3

The *indications* for spinal manipulation have mostly been dealt

APPENDIX II

MANIPULATION—EPIDURAL INJECTION—SERIAL PLASTERS

Under certain conditions, manipulation of a joint or joints is the only method by which improvement in joint function or relief of pain can be achieved This has been recognised more and more within recent years. It behoves anyone, therefore, especially interested in rheumatism and locomotor disorders to study and learn all he can of the movements to be expected in joints under normal circumstances at different ages, in order that a yardstick may be established by which to judge whether or no a joint is moving in the *normal fashion* and *at the correct range*. When this has been mastered, however, it cannot be applied indiscriminately, and the best criterion ultimately is to judge a joint by comparison with its fellow of the opposite side, if it be sound. In spite of this, the knowledge so acquired is essential if joints are to be moved under an anæsthetic. The following principles govern manipulation of any and all joints:

1 No joint should be manipulated until a thorough course of physiotherapy and active and assisted movements have been given, and no further improvement is being gained.

2 In cases where arthritis has been a factor, it is unwise to manipulate whilst tenderness and muscle spasm can still be detected. This rule is absolute only for the general practitioner, the expert may on many occasions manipulate a joint which is still the site of active arthritis, but the knowledge, skill and judgment which enable this to be done cannot, unfortunately, be imparted in a book.

3 Manipulation should always be accompanied by massage and stretching of the muscle groups concerned, both the agonists and the antagonists

4 The actual manipulation should never be carried out against time It takes a careful man 30–40 minutes to manipulate a spine and it cannot be properly done in less A great many manipulative failures can be traced to an urge for speed It stands to reason that no one can undo in ten minutes processes which have taken months or years to build up.

5 Cases which show great restriction of movement should be manipulated in stages The great Sir Robert Jones took the view that one movement of a joint should be restored at a time in these cases

6 The after-treatment of manipulated joints is as important as the manipulation itself The man responsible for the manipulation should supervise the after-treatment himself. He is the only man who knows the target he set himself, and who can therefore judge the progress being made.

Perhaps the most successful types of case are those of traumatic origin, which come into the purview of the orthopædist. Many of

and repeated with the upper thigh flexed to varying degrees. It is generally called the "pelvic twist"

While on the side circumabduct the upper shoulder to its full range

With the patient prone fix the ribs on the right side with the left hand at different levels and pull up the right anterior superior spine towards you. This tends to free the costovertebral joints Hyperextend the hips holding the lumbosacral joint with the other hand

Flex the knees and rotate the hip joints by moving the foot sideways

Repeat the manipulation for the dorsal spine on the other side from the right-hand side of the table

Repeat the pelvic twist and the circumabduction of the upper shoulder with the patient on his left side

Sit the patient up (with the consent of the anæsthetist) and forcibly flex the whole spine This is the most difficult manœuvre to do with success

In any case of doubt manipulate the feet at different levels

This represents a complete manipulation for all ordinary medical purposes Certain special orthopædic movements are omitted these are best left to the orthopædic surgeon

It has always seemed beneficial to do a full manipulation in most medical cases In a case of periarthritis of the shoulder, for instance, lack of movement and "adhesions" are often found in the cervical spine, and indeed other parts of the spine Failure to manipulate the feet results in some disappointing spinal manipulations An important point is to try to *put traction on the parts being manipulated*

Lateral movement of the spine is rather limited and usually accompanied by rotation Special manœuvres to produce lateral movement have been suggested from time to time but are not very helpful

Epidural Injection

The theory which lies behind this form of treatment is, that if the epidural space is filled with fluid under pressure, small adhesions along the exit of the nerves from this space will be ruptured and pain alleviated

The *sacrococcygeal foramen* (hiatus sacralis) is situated at the level of sacral 5 The spine of S5 is usually absent and as the laminæ do not coalesce medially a gap is left, bounded on each side by two downward projecting processes, the sacral cornua These are the landmarks to the *inferior aperture of the sacral canal* It is through this aperture that the injection is made

Technique

Some authors have suggested that this method can be used in Out-Patient Departments This is most unwise and should be discouraged. The patient should be admitted to hospital the day before, and an enema should be administered

with in the text The *main ones* are: (*a*) A spine which is stiff and painful without any known pathology. The presumption here is that the stiffness is due to periarticular and interfascial adhesions. (*b*) A spine of the same type which is giving rise to sciatica and girdle pain. The chapter on Sciatica deals with the question of excluding a prolapsed nucleus pulposus. In these cases manipulation has been known to lead to paraplegia from cord pressure (*c*) Cases of osteoarthritis of the spine without marked osteophytes. (*d*) Cases of postural deformity of recent standing where it is intended to use plaster. (*e*) Some cases of recurrent lumbago. (*f*) Some cases of occipital neuralgia (*g*) Some cases of unknown origin, generally labelled sacro-iliac strain or lumbosacral strain.

Method

With the patient lying supine and under anæsthesia, each thigh is flexed in turn, and with the knee also flexed, and held in one hand, the foot is pushed and pulled sideways, so rotating the head of the femur Continue … until, with the thigh anc … with the body. Take t … highs, raising the lumbar and dorsal spines well on the table Fix the pelvis by downward pressure. … thighs as far as possible and th … these movements deep knead t … again Straighten the knees … pressing gently on the knee joint. *When straight move slowly in* flexion and extension until the best possible movement is obtained, and test for lateral stability

Press with some force on to the chest and at the end of a deep inspiration *suddenly release.*

Take each elbow in turn with one hand and with the other rotate the humerus in the glenoid fossa, gradually raise and rotate the arm as you do so, until it lies right round the neck. Check that this movement is taking place at the glenohumeral joint, and also that the scapula is mobile in the chest wall.

Pull the patient up the table so that the head is over the edge. Holding it with both hands, rotate it fully in both directions.

Holding it with one hand, and with the other round the neck, *bend the neck sideways in both directions*, holding the spine steady at various levels Fully flex and extend. Keep a little tension on the spine all the time. Turn the head 45° in each direction in turn and extend the head half-way between ordinary extension and sideways bending

With the patient on his right side and the upper leg hanging over the edge of the table, slightly twist the spine by pulling on the under arm. Holding the upper shoulder back *with one hand, give a fairly* … as to twist the spine further. As an … y be placed across the upper buttock … the same time pushing the shoulder away. This is a powerful movement and should be done carefully

APPENDIX III

TECHNIQUE OF JOINT AND MUSCLE INJECTIONS

The technique of joint injections is approximately the same as the technique of aspiration, except in those very unusual cases where the injected solution is intended to reach a particular place in the joint In these cases a special technique will have to be adopted to suit the circumstances

The danger of infection of the joint must always be borne in mind and thorough aseptic precautions are necessary The procedure can be a very painful one and local anæsthesia should always be used Novocaine should first of all be injected intradermally to make a wheal at the spot where the needle will penetrate It is as well to wait a moment of two until the anæsthetic effect is obtained, when the needle is plunged through the area already marked out, the *novocaine being injected as the needle penetrates It is important* to anæsthetise the synovial membrane, which is very sensitive It is not as a rule practicable to use the same needle for the aspiration as for the local anæsthetic The needle for aspiration should be of a wide bore as in pathological cases the fluid is very liable to clot In the course of aspiration the skin should be pulled back and the needle inserted so that the track may be obliterated afterwards After aspiration, the joints should be tightly bandaged to prevent, if possible, the recurrence of the effusion, but not so tightly as to interfere with the circulation

Sites for Aspiration

Ankle—The needle should be inserted in front of the internal malleolus

Knee—There is a fairly wide choice here Where the effusion is large it generally seems better to go through the infrapatellar space on either side, but where it is small, and especially in those cases where synovial proliferation is a marked feature, the suprapatellar pouch is preferable

Hip—This is the most difficult joint to aspirate The easiest approach is from a point one inch above the great trochanter in a vertical line It is a good thing to outline the great trochanter with a skin pencil and then to draw a line upwards towards the iliac crest and take a point one inch along this line With the patient supine the needle, after local anæsthesia has been carried out, should be driven in at right angles This should hit off the capsule of the joint and it has always seemed the best and easiest method of approach. The needle must be kept exactly at right angles Most text-books, however, say that the point to take is one inch below Poupart's ligament immediately lateral to the femoral artery

The skin over the sacrococcygeal foramen and its neighbourhood should be washed with soap and water, painted with picric acid and covered with a sterile dressing Sodium amytal gr. 3 should be given to ensure a good night

The injection should be done under general anæsthesia in the theatre, and the skin again painted and covered with sterile towels With the patient on his face the two tubercles described are identified and a Howard's lumbar puncture needle is pushed into the hiatus Slightly tilted forward for the puncture the hand should then be dropped to allow the needle to run forward into the epidural space Having withdrawn the trocar a sterile syringe is fitted on to the cannula and suction made to be sure cerebrospinal fluid is not withdrawn A two-way stopcock is fitted to the syringe, which is connected via rubber tubing to a can containing sterile normal saline The amount to be injected is the subject of some controversy and must be judged to some extent by the degree to which the pressure (as judged by the difficulty of injection) rises It is seldom good policy to put in less than 300 c c and 500 c c is often required. The needle is withdrawn, and collodion applied. Anyone who has once seen an epidural abscess will agree that nothing less than the above precautions is wise.

This *treatment* is mostly used for sciatica of unknown origin, and often in conjunction with manipulation

Serial Plasters and Splints

Serial plasters have come into their own in recent years. They are much used by physicians especially in rheumatoid arthritis and for the knees

The knee (and the hip and ankle, if desired) is put into the best position obtainable, and a light plaster-of-Paris case applied. After 3–4 days this is taken off, and it will be found that swelling and spasm of muscle has abated a good deal The limb is put through its passive movement to the permissible extent If the position is still unsatisfactory another plaster is applied for 3–4 days The same process can be repeated, and as soon as a satisfactory position is assured the plaster is "bi-valved" and the limb put through its full range every day At the same time the muscles may be exercised with mild faradism until the patient can make active movements

Plaster slats are often used for arthritic hands and wrists. Four or five lengths of "Cellona" plaster-of-Paris bandage are doubled up one on the other until a piece of the required length is obtained It is then dipped in water for four seconds and applied to the hand and wrist and moulded on until it sets This is bandaged on to the patient at night, and it is really amazing how effective it may be.

Splints are available in many forms, but it always seems that plaster is preferable for the physician, as it can be exactly adapted to his requirements in many cases.

If further mechanical help is needed, it is wise *to consult an orthopædist*

muscle The needle is inserted at this point and pushed forward at right angles to the skin At a depth of about 5 cm. bone is usually



Fig 262

Surface marking of the pyriform muscle, the perpendicular is three-quarters of an inch long

reached The needle is slightly withdrawn and 10 c.c. of 1 per cent. procaine is slowly injected In cases where the pyriform muscle is at fault the sciatic pain will be relieved for several hours

Wrist.—The head of the ulnar should be carefully outlined and the needle driven in just below this on the dorsum.

Elbow.—The best point here is between the coronoid process of the humerus and olecranon process.

Shoulder—This is best approached from the back through the deltoid muscle.

Other joints offer little difficulty as they are superficial.

The same sites are used for the injection of air when it is intended to take an arthrogram.

Technique of Injection of the Scalenus Anterior Muscle

It is as well to have the patient lying on his back with the head on a small pillow. If the injection is given sitting up these patients sometimes faint.

Turn the head away from the side of the injection, and palpate the lateral border of the sternal head of the sternomastoid muscle. At the same time the forefinger is placed about three-quarters of an inch laterally and the clavicular head of the muscle is pushed medially. Press downwards and backwards fairly hard behind the clavicle until *the belly of the scalenus anterior can be felt. Follow the course of* the muscle upwards for one and a half inches, and inject about 5 c c. of a sterile 1 per cent procaine solution. This solution is prepared by adding [illegible] 100 c c. saline. If adrenaline is used [illegible] 0·5 c c. will be sufficient for the abc[illegible] *made* on the needle before injection to prevent the solution entering the vascular system.

Difficulties—The *stellate ganglion* lies at the level of T1 on the neck of the first rib. If it is injected by mistake Horner's syndrome *may appear* (*miosis, enophthalmos, ptosis, absence of sweating,* and conjunctival injection). This generally disappears in about an hour The phrenic nerve may be injected, or the brachial plexus may be affected Either or both will recover in about the same time.

Procaine injection of the scalenus anterior is partly diagnostic but sometimes therapeutic, and is used for separating out lesions such as the costoclavicular syndrome, cervical rib, the scalenus anterior syndrome and acroparæsthesiæ.

Technique for the Injection of the Pyriform Muscle

The injection is carried out with full aseptic precautions. The best position for the patient is to lie on the unaffected side with the upper thigh somewhat flexed.

The upper border of the great trochanter is outlined with a skin pencil, and the posterior superior iliac spine is identified and marked The two points are joined. From the mid-point of this line a perpendicular is dropped at right angles (see Fig. 262). One and a half inches down this line marks the site of exit of the sciatic nerve from the pelvis. A point slightly above this (three-quarters of an inch down the perpendicular) marks the site for injection of the pyriform

APPENDIX V

MUSCLE NERVE TESTING

For this technique one electrode is applied to the part of the muscle where the nerve usually comes nearest to the surface, this is called "the motor point"; the other to some indifferent area such as the back. Either the faradic (induced) current or the galvanic (continuous) one-way current may be used.

If the *galvanic* or battery current is used either the anode or the kathode may be applied The contraction which occurs on closing the circuit with the kathode placed on the muscle motor nerve point is greater than that which occurs when the anode is used (K C C > A C C.) At break, the opposite state of affairs is found (A O C > K O.C.).

When the so-called "reaction of degeneration" (R D) is present no reaction is obtained to faradism, and the galvanic polar phenomenon may be absent or reversed (e g A C C >K C C) This galvanic contraction is slow and "worm-like" Sometimes the greatest reaction is not over the motor point but over the tendon of the muscle These findings indicate nerve degeneration, and are said to be due to stimulation of the muscle itself If only part of a muscle has degenerated, "partial R D " may be found

When some skill has been acquired in this technique it may be found more accurate to employ the *bipolar method*, using two small electrodes and putting them both on the muscle to be tested at different points This localises the stimulus to the muscle being tested, and so excludes the "group reaction" sometimes obtained by the other method

Two other types of reaction occur, the "myasthenic" reaction, when the muscles respond normally but tire very quickly, and the "myotonic" reaction, when contraction occurs in the usual way but relaxation is very slow

Chronaxie

If the minimum voltage capable of producing a contraction is applied for a time to a muscle and its value ascertained, this value is termed the *rheobase* for that muscle Chronaxie is *the time* during which a current twice as great as the rheobase must flow through a tissue to set up activity (Samson Wright, 1942) The chronaxie of frog's skeletal muscle is 0 3–0·9 m sec

Following section of a motor nerve, and when it has completely degenerated, the chronaxie of both muscle and nerve is said to rise. A long chronaxie indicates a slowly acting tissue, hence the "worm-like" contraction previously mentioned as part of the R D. state. For the same reason the short faradic stimulus is never so long as the chronaxie and so produces no contraction

REFERENCE

WRIGHT, SAMSON *Applied Physiology* Humphrey Milford, Oxford University Press, London

APPENDIX IV

OPTIMUM POSITION FOR ANKYLOSIS

In many of the conditions dealt with in this book the problem of ankylosis becomes of great importance. The question of the optimum position will have to be considered some time before the necessity arises. *The following table gives the positions which are best and* most convenient for the patient.

Ankle.—The best position here is at a right angle and it is important to remember to keep the ankle in line with the leg.

Knee—About 5–10 degrees of flexion seem to give the best result In some cases the knee is ankylosed in a state of complete extension This has always seemed to have some disadvantages.

Hip—It is quite evident that the best position for sitting will be the worst for standing and vice versa The best that can be done, therefore, is to try to strike a suitable compromise; about 15 degrees of flexion allows the patient to sit with some comfort and at the same time to get about fairly well. The hip must be abducted to some extent and it is convenient to have a little external rotation.

Wrist—A little dorsal tilt is convenient.

Elbow.—The important point here is to have a position which allows the hand to reach the mouth, even if this is done only with difficulty The best position for this is just more than a right angle, about 100 degrees The position must be carefully reviewed if the radio-ulnar joints are affected In this case the best position is half-way between supination and pronation.

Shoulder—This should be in a position of slight abduction and an appreciable degree of flexion.

INDEX

APPENDIX VI

CERTAIN NORMAL BLOOD VALUES

Serum calcium—10–11 5 mg. per 100 ml.
Blood cholesterol—100–200 mg. per 100 ml.
Serum acid phosphatase—under 4 Gutman units.
Serum alkaline phosphatase—adult, 4–14 units; child, 6–20 units. (King and Armstrong.)
Blood sedimentation rate—normal distance at end of the first hour, 2–8 mm.; at end of second hour, 8–16 mm.

These are the normals for most standard methods. The different methods are not comparable where abnormal values are concerned. The Westergrĕn method is commonly used. It is considered by some authors that the normal figures vary in the case of males and females. Personal experience leads one to doubt this and, therefore, separate figures have not been given for the two sexes.

Fasting blood sugar—75 mg. per 100 ml.
Blood urea—20–40 mg per 100 ml.
Blood uric acid—male, 3–3·8 mg per 100 ml.; female, 2–3·5 mg. per 100 ml.
(See chapter on Laboratory Methods)

INDEX

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